ARI Contractor Report 2002-07

Results of the Data Analysis Army Aircrew Coordination Measures Testbed Conducted Spring 1990

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October 2001

United States Army Research Institute for the Behavioral and Social Sciences

REPORT DOCUMENTATION PAGE

1. REPORT DATE (dd-mm-yy) October 2001	2. REPORT TYPE Final	3. DATES COVERED (from... to) Jan 92 – Dec 92

4. TITLE AND SUBTITLE Results of the Data Analysis Army Aircrew Coordination Measures Testbed Conducted Spring 1990	5a. CONTRACT OR GRANT NUMBER MDA903-87-C-0523 5b. PROGRAM ELEMENT NUMBER
6. AUTHOR(S) Robert Simon (Dynamics Research Corporation)	5c. PROJECT NUMBER 5d. TASK NUMBER 5e. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Dynamics Research Corporation Systems Division 60 Concord St. Wilmington, MA 01887	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Research Institute for the Behavioral and Social Sciences Attn: TAPC-ARI-IR 5001 Eisenhower Avenue Alexandria, VA 22333-5600	10. MONITOR ACRONYM ARI 11. MONITOR REPORT NUMBER Contractor Report 2002-07

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

Dennis K. Leedom, COTR

14. ABSTRACT *(Maximum 200 words)*:

This is one of thirteen archival reports from a series of research and development contracts dealing with aircrew coordination.

15. SUBJECT TERMS

Aircrew coordination

SECURITY CLASSIFICATION OF			19. LIMITATION OF ABSTRACT	20. NUMBER OF PAGES	21. RESPONSIBLE PERSON (Name and Telephone Number)
16. REPORT Unclassified	17. ABSTRACT Unclassified	18. THIS PAGE Unclassified	Unlimited	210	Dennis Wightman DSN 558-2834

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Working Paper

WP ARIARDA/DRC 92-05

Results of the Data Analysis Army Aircrew Coordination Measures Testbed Conducted Spring 1990

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MDA903-87-C-0523

December 1992

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Contract MDA903-87-C-0523

E-17639U

Contract #ASI SUBTR-690-90-5

~~TECHNICAL REPORT~~: RESULTS OF THE DATA ANALYSIS ARMY AIRCREW COORDINATION MEASURES TESTBED CONDUCTED SPRING 1990

1 April 1991

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Section 1.0
Introduction

1.1 Background

Under separate contract to the Army Research Institute Aviation Research and Development Activity (ARIARDA), Dynamics Research Corporation (DRC) developed three measures (instruments) of crew coordination: one attitude-based measure and two performance-based measures.

- o The attitude-based measure is the Army Cockpit Management Attitudes Questionnaire (Army CMAQ). The Army CMAQ is a questionnaire asking aviators to rate the extent of their agreement/disagreement to 45 statements regarding their attitudes towards aircrew coordination. Agreement/disagreement is recorded using a 7-point Likert scale. The Army CMAQ can be found at Appendix A.1.

- o One of the performance-based measures of behavior is the Aircrew Coordination Evaluation Checklist (ACE Checklist). The ACE Checklist is filled out by an observer/ evaluator, typically an Instructor Pilot (IP). The ACE Checklist consists of 19 aircrew coordination-related behaviors with each behavior rated on a 7-point scale ranging from Very Poor to Superior. All 19 behaviors are described and "behaviorally anchored" at the 1, 4, and 7 level. The ACE Checklist (without the behavioral anchors) can be found at Appendix A.2.

- o The other performance-based measure of behavior is based on revisions to the tasks defined in TC 1-212, Aircrew Training Manual Utility Helicopter, UH-60 (hereinafter referred to as ATM Tasks). Revisions were made for the purpose of including aircrew coordination considerations into selected ATM Tasks. ATM Task performance was rated as an A, B, C, or U using a modified standard form gradeslip. The modified gradeslip used in this study can be found at Appendix A.3.

A complete description of the development of the measures and all supporting documentation is contained in Technical Report: Development of Measures of Crew Coordination dated 31 August 1990 (hereinafter referred to as the Development of Measures technical report).

In this report, DRC provides the results of a data analysis that examined the functional relationships between aircrew coordination attitudes, aircrew coordination behaviors, and mission performance. Under the sponsorship of ARIARDA, DRC collected the data for this analysis at Fort Campbell during the Spring of 1990 and at Fort Rucker during the Summer of 1990.

The remainder of this Section reports on the methodology and sample used for the data collection. Sections 2 through 5 report on the internal properties of the measures used in the study. Sections 6 through 9 present a variety of correlation-type analyses used to determine the relationships among the measures. Section 10 contains a summary and conclusions based on the

previous Sections; potential additional studies are suggested which may be of interest to the Army.

1.2 Methodology and Sample Description

As depicted in Table 1.2-1, there were several administrations of the three aircrew coordination (AC) measures. Additionally, one other instrument was used as part of a broader administration of the Army CMAQ at Fort Campbell on 30 May 1990. At that time, unit Instructor Pilots (IP) were asked to provide "quality ratings" on aviators within their unit using a predefined, standardized measurement form and scale. This form is at Appendix A.4.

Data collection used the following organizations and personnel:

- Testbed Aviators - Forty aviators comprising twenty crews from the 101st Aviation Regiment participated in the May 90 testbed. The twenty crews were given an identical two-hour tactical mission to fly in the UH-60 flight simulator. All forty aviators completed the Army CMAQ; the twenty crews were rated on the ACE Checklist and ATM Tasks.

- Testbed IPs and I/Os - Three IPs, serving as raters of aircrew performance, and four simulator Instructor/Operators (I/O), serving as simulator operators, participated in the testbed. These seven individuals were given familiarization training in the principles and practice of aircrew coordination; then fully trained to implement the testbed simulation procedures and the rating instruments. As part of their familiarization training in aircrew coordination, the IPs and I/Os were administered the Army CMAQ before and after training.

- 101st Avn Regiment - Subsequent to the testbed, eighty (80) aviators from the 4th, 5th and 9th Aviation Battalions of the 101st Aviation Regiment were administered the Army CMAQ on 30 May 90. Of those 80 aviators completing the Army CMAQ, 58 aviators received "quality" ratings from their unit IP.

- USASC - United States Army Safety Center (USASC) personnel were trained during June-July 90 in methods to incorporate aircrew coordination considerations into accident investigations. DRC fully trained 20 USASC personnel; an additional two USASC personnel were able to only partially complete the training. Twenty (20) USASC personnel were administered the Army CMAQ prior to training; of those 14 also completed it subsequent to training.

Different sample sizes are used in the analyses. To decode the meaning, each is defined below:

n=20:	the twenty testbed aircrews.
n=40:	the forty testbed aviators.
n=80:	Fort Campbell aviators taking the Army CMAQ on 30 May 90.

n=58:	Fort Campbell aviators taking the Army CMAQ on 30 May 90 who also received "quality" ratings from their unit IP.
n=168:	all those who took the Army CMAQ under all conditions/places.

There is, of course, some missing data. On these occasions, a particular equation or result within a Table is based on slightly fewer subjects than the "n" noted in the Table.

Table 1.2-1
Administration of the
Aircrew Coordination Measures

Sample	Location	Army CMAQ	ACE	ATM Tasks	Quality Ratings
Testbed aviators	Ft. Campbell	X (n=40)	X (n=20)	X (n=20)	
Testbed IPs & I/Os	Ft. Campbell	Pre- & Post (n=7)			
101st Avn Regiment	Ft. Campbell	X (n=80)			X (n=58)
USASC	Ft. Rucker	Pre (n=20) Post (n=14)			
Total	All	n=168	n=20	n=20	n=58

Section 2.0
Properties of the Army CMAQ

2.1 General

Scales and scale scores were created for the Army CMAQ. The Army CMAQ subscales were slightly modified from the initial scales, but were still based on the conceptual framework presented in the Development of Measures technical report. The data collected at Ft. Campbell and USASC were based on the first administration of the Army CMAQ, the initial version of which can be found in Appendix A.1. Frequency distributions were computed for each CMAQ item; and item analyses were performed for each of the derived CMAQ subscales. Frequency distributions and scale construction are further discussed below.

2.2 Frequency Distribution

Appendix B contains frequency distributions for all 45 Army CMAQ items. [Note: the 45 CMAQ items are referred to sequentially as C1 to C45.] Respondents availed themselves of the entire seven point rating scale; therefore, most items have a reasonable amount of variability associated with them.

2.3 Scales and Scale Construction

During the initial development of the Army CMAQ, DRC constructed five subscales comprising all 45 items of the Army CMAQ. During the current research phase, the scales were refined and reorganized into four subscales as summarized below:

1) The attitude previously summarized as "Values Crew" was redefined as "Values Teamwork." In accordance with this change, Table 2.3-1 describes the revised linkages between between beliefs, attitudes, and behaviors (Table 2.3-1 may be compared to Table 2.3-5 of the Development of Measures technical report). Note that the third column labeled, "essential crew attitudes," is the column that has been altered.

2) The two attitude areas previously summarized as "Get Information" and "Give Information" were combined for two reasons: one reason being that combining "give" and "get" made the attitude area better aligned with the "Provide/Accept Help" attitude area, i.e., sharing information, like helping, is now a "two-way street;" the second reason was that combining the two subscales increased the number of items appearing in the subscale, thus improving reliability.

3) The items were uniquely placed into each subscale. While it was conceptually possible that items could fall into more than one attitude area, consideration had to be given to the ramifications for subsequent data analyses; e.g., correlations and regressions. If items were allowed to appear in more than one subscale, then the subscales would be dependent upon

Table 2.3-1
Linkages Between Beliefs, Attitudes, and Behaviors (Revised)

Old Implicit Beliefs	New Explicit Beliefs	Essential Crew Attitudes	Behavioral Objectives in Crew Coordination
o Beyond the pilot, the rest of the crew is backup and basically unimportant to the mission.	o The entire crew is critical to mission success.	o My fellow crewmembers are an important resource; I need to treat them with respect and use them as valued members of a team. **(Values Teamwork)**	o Establish and maintain interpersonal relationships to create and maintain a haonious team atmosphere and to execute mission objectives. **(Establish/Maintain Team Relationships)**
o Pilots are infallible in their flying skills.	o All crewmembers make mistakes. o Crewmembers can catch other crewmembers' mistakes before they have serious consequences.	o Human errors are a fact of life; everyone makes them; they should be corrected with minimum disruption to ongoing tasks, mission execution or ~~to~~ team relationships. **(Crew Fallibility)**	Check each other's actions for possible errors. **(Cross Monitoring of Crew Performance)**
o Pilots are aware of all available decision options. o Pilots can collect and integrate all important decision information alone. o Pilots operating alone make the best decisions. o We can figure things out during the mission. We have to remain flexible.	o A qualified crew will surface a greater range of decision options than the pilot alone will produce. o A more complete set of decision support information will be generated by the crew then by the pilot alone. o On average, decisions which consider crew recommendations will be better than decisions made by the pilot alone. o Once airborne, there may be little time to develop and coordinate actions and decisions. Contingencies and options should be developed and discussed before the need arises.	o Other crewmembers may provide information that I have not considered; I need to take actions to ensure delivery of this information to the group. o I may have information which is important to another crewmember; I must take actions to ensure that he receives this information in a timely manner. **(Give/Get Information)**	o Establish and maintain the same mission plan and a common frame of reference within each crewmember's mind in as much detail as possible. o Expose the decision maker to the full range of action options available at each imporatnt decision point. **(Mission Information Exchange)**
o Pilots can handle all workload alone.	o The quality of mission task performance is highest when the workload is effectively distributed across crewmembers. o Crews can effectively distribute task execution responsibilities.	o Overloads increase the risk of errors and poor mission performance; providing support to overloaded crewmembers is essential to effective mission execution. **(Provide/Accept Help)**	o Allocate workload in a reasonable manner across crewmembers. **(Establish/Maintain Reasonable Workload Levels)**

one another and the results would be difficult to interpret. Using Table 2.3-1 for guidance, DRC analysts uniquely placed the Army CMAQ items into distinct "logical" subscales based on subjective judgements concerning the attitude area best matched by the item. In accordance with this change, Table 2.3-2 presents the new organization of the Army CMAQ items into the "logical" subscales and updates the subscale organization previously defined in Table 5.1-1 of the Development of Measures technical report.

Table 2.3-2
Placement of Army CMAQ Items into Subscales

Army CMAQ Subscale/ Attitude Area	Army CMAQ Item Number
Values Teamwork	1, 4, 5, 7, 8, 9, 15, 19, 22, 25, 26, 27, 29, 30, 42, 44, 45
Crew Fallibility	6, 11, 12, 14, 17, 18, 20, 21, 28, 38, 41
Give/Get Information	2, 10, 13, 23, 24, 31, 32, 33, 34, 43
Provide/Accept Help	3, 16, 35, 36, 37, 39, 40
Total	1 to 45

2.4 Army CMAQ Reliability Statistics

Respondents answered the 45 Army CMAQ items using a 7-point scale ranging from Strongly Disagree (value = 1) to Strongly Agree (value = 7). For 24 of the 45 items, the desirable, or "correct," attitude was a value of 7. The remaining 21 items were negatively worded so that a value of 1 was the desirable or "correct" attitude. Before proceeding with the analyses, all items were "scored." The scoring key is provided at Table 2.4-1.

Table 2.4-1
Item by Item Scoring Key Employed with Army CMAQ Items

Item Numbers for <u>"Agree" = Correct</u>	Item Numbers for <u>"Disagree" = Correct</u>
2, 3, 4, 5, 6, 7, 8, 10, 13, 15, 16, 17, 18, 19, 23, 25, 28, 30 31, 32, 33, 36, 37, 44	1, 9, 11, 12, 14, 20, 21, 22 24, 26, 27, 29, 34, 35, 38, 39, 40, 41, 42, 43, 45

After "scoring" the responses to the items, several types of reliability analyses were performed on each of the four subscales and the total score. The reliability statistics calculated for the Army CMAQ include Cronbach's Alpha, Split-Half, and Test-Retest reliability statistics (Table 2.4-2). Cronbach's Alpha and Split-Half reliabilities were calculated based on the entire sample of subjects administered the Army CMAQ (n=168); one case, however, was dropped due to missing data. Test-retest reliability was calculated based on those subjects administered the Army CMAQ on two different occasions (n=35). This group included testbed aviators who participated in the May 90 Army CMAQ administration, testbed IPs and I/Os, and USASC personnel.

Table 2.4-2
Comparative Scale Reliability Statistics for the Army CMAQ (n=168)

Scale Name	# of Items	Avg.Item Mean	Scale S.D.	Reliabilities** 1	2	3	4
1) Total	45	5.47	.38	.78	.66	.75	++
2) Values Teamwork	17	5.26	.45	.51	.33	.57	.42
3) Crew Fallibility	11	5.23	.58	.52	.44	.59	.50
4) Give/Get Information	10	5.83	.52	.64	.48	.81	.67
5) Provide/Accept Help	7	5.83	.51	.55	.44	.40	.61

** Reliabilities:
1 = Cronbach's Alpha (n=167)
2 = Split-Half (n=167)
3 = Test-Retest (n=35)
4 = Cronbach's Alpha (n=40, testbed aviators)
++ Determinant of matrix is zero; could not be computed.

As Table 2.4-2 shows, the reliability coefficients of the Army CMAQ and the subscales are good and are similar to those reported by the NASA/UT Crew Performance Project (Gregorich et al., 1990). The NASA/UT project's three subscales were derived based on a factor analysis. Cronbach Alphas were reported for CMAQs given to personnel from three commercial airlines, the third of which had the CMAQ administered in a pre- and post-training condition (Table 2.4-3). The NASA/UT subscale reliabilities range from .46 to .67; DRC/ARIARDA's subscale reliabilities range from .51 to .64 for a much smaller sample.

Table 2.4-3
Cronbach's Alphas for a Three Subscale CMAQ as Reported by NASA/UT (Gregorich et al., 1990)

Scale Name	Airline A (n=374)	Airline B (n=3774)	Airline C Pre-test (n=696)	Airline C Post-test (n=701)
Communication & Coordination (11 items)	.57	.67	.63	.67
Command Responsibility (4 items)	.52	.46	.48	.47
Recognition of Stressor Effects (4 items)	.60	.52	.59	.60

A correlation matrix (Table 2.4-4) was generated to show the relationship among the Army CMAQ scales.

Table 2.4-4
Army CMAQ Subscale Correlations
(n=168)

Scale Name	Total	Values Teamwork	Crew Fallibility	Give/Get Info	Provide/ Accept Help
Total	---				
Values Teamwork	.82	---			
Crew Fallibility	.74	.45	---		
Give/Get Info	.77	.47	.40	---	
Prvde/Accpt Help	.60	.32	.24	.53	---

A comparison of the subscale correlations to the NASA/UT inter-composite correlations showed the Army CMAQ correlations to be higher. The NASA/UT correlations ranged from .00 to .27 (correlations were not provided for the Total score with the subscale factors). Note that the correlations of the Total column in Table 2.4-4 with the subscales are high since subscale items are embedded within the Total score. It is desirable when constructing subscales that the relationships among them be low since that implies the subscales are assessing different attributes. In the case of the Army CMAQ data the subscale correlations are relatively low, but not as low as those the NASA/UT project showed from data collected in the commercial aviation sector. It may be that the higher inter-scale correlations of the Army CMAQ are due to the manner in which Army aviators understand aircrew coordination; Army aviators may view aircrew coordination as a more integrated concept with the subscales being more mutually supportive of one another.

2.5 Factor Analysis of the Army CMAQ

A factor analysis was performed on the Army CMAQ data to determine if alternative, and perhaps more meaningful scales could be developed. To capture the underlying factors as presented by "field" Army aviators, the sample used in the factor analysis was limited to Army unit aviators: i.e., the eighty (n=80) Ft. Campbell aviators administered the Army CMAQ in May 1990.

When the 45 Army CMAQ items were factor analyzed without constraints, a 15-factor model resulted. Since a 15-factor model proved unwieldy, the data were alternatively limited to four, and then three factors. The four factor model was not readily interpretable; the items did not collect in an explicable manner. The three-factor model proved most interpretable. The rotated

(varimax) factor matrix converged in 9 iterations with 30.7% of the variance explained. Table 2.5-1 shows how the items loaded on each factor. Note that the items in Table 2.5-1 are labeled C1 through C45. These labels correspond to the 45 item numbers in the Army CMAQ found in Appendix A.1.

The three factors shown in the Table 2.5-1 are similar to the ones discussed by NASA/UT (Gregorich, et al, 1990). In that article, the authors named the factors "Communication and Coordination", "Command Responsibility", and "Recognition of Stressor Effects."

Since the factor analysis of the Army CMAQ resulted in "reasonable" factors and because the Army factors closely approximated previous research, it was decided to further explore the "factor" scales in addition to the "logical" scales discussed in previous sections. Since the Army CMAQ contains 45 items, and the NASA/UT CMAQ contains 25 items (19 of which were "consistently identified" across the four samples as loading on a particular factor), an approach for categorizing the Army CMAQ items into the three factor scales was developed based on three decision rules:

1) Army CMAQ items 1 through 21 were included in a scale if they loaded similar to the NASA/UT CMAQ items,

2) Army CMAQ items 22 through 45 were placed into the scale on which their highest loading occurred; and

3) Negative highest loadings (specifically items 25 and 29) were excluded from the scales.

Placement of the 34 Army CMAQ items meeting the above criteria into the three factors is shown in Table 2.5-1.

Table 2-5.1
Factor Analysis Results for the Army CMAQ
(n=80)

CMAQ Item #+	FACTOR 1 (Comm & Coord)	FACTOR 2 (Shared Ldrshp)	FACTOR 3 (Stressors)
C1	.04600	.29676	.36115
C2	.41243*	.28932	-.22092
C3	.28068	.09211	-.28248
C4	-.12962	.40165	-.13770
C5	.19132	-.26749	.54709
C6	.58756*	.20298	.00737
C7	.57549*	.31658	.12830
C8	.51250*	-.01470	.38057
C9	-.49295	.20670	.25609
C10	.27342	.34128	-.09177
C11	-.34842	.03082	.43091
C12	-.01262	.03260	.41666*
C13	.21929*	.09648	.04967
C14	-.21957	.59598*	.15562
C15	.65339*	.26947	-.00042
C16	.53773	-.07450	.11731
C17	.01410	-.13229	-.39910
C18	.61427*	-.03345	-.04611
C19	.61589*	.07438	-.02910
C20	.11052	.07188	.60121*
C21	-.17113	.01174	.48509*
C22	-.41596	.34817	.50407*
C23	.52093*	.48507	-.18701
C24	.26311	.38707*	.31534
C25	-.18785	-.24067	.20237
C26	.01557	.37260*	.09224
C27	.36661	.72399*	.04169
C28	.26037*	-.11576	.06070
C29	-.36824	.19315	.29994
C30	.25185*	.08104	.04709
C31	.53099*	.16719	-.03701
C32	.18946	.33896*	-.01618
C33	.52965*	.40418	-.25547
C34	.11832	.35523	.48046*
C35	.17714	.59047*	-.00225
C36	.65711*	.31763	.08394
C37	.49190*	.13966	-.19401
C38	.20497	.42666*	.24625
C39	.05080	.48586*	.15605
C40	.29671*	.23765	.17983
C41	.13690	.36576	.47943*
C42	.05746	.53636*	.01603
C43	.04969	.32444*	.15793
C44	.30252*	-.17383	.26656
C45	.06307	.44219*	.29971

* Item included in this "factor" scale.
+ CMAQ Item # C1 to C45 are CMAQ item numbers 1 to 45.

Note that Factor 2 has been renamed from the NASA/UT nomenclature of "Command Responsibility" to "Shared Leadership" to provide a better description of the factor. To summarize, 34 Army CMAQ items were selected and placed into three "factor" scales as a result of a factor analysis and several decision rules. The resulting Army CMAQ "factor" scales are shown in Table 2.5-2.

Table 2.5-2
Placement of Army CMAQ Items into the "Factor" Scales

Factor #	Scale Name	Army CMAQ Items in Scale
1	Communication & Coordination	C2, C6, C7, C8, C13, C15, C18, C19, C23, C28, C30, C31, C33, C36, C37, C40, C44
2	Shared Leadership	C14, C24, C26,C27, C32, C35, C38, C39, C42, C43 C45
3	Recognition of Stressor Effects	C12, C20, C21, C22, C34, C41
Overall	(34 "selected" items)	All above listed items.

Factor definitions:

1) **Communication & Coordination** - an orientation toward interpersonal awareness, communication, and crew coordination. Example items are:

"Crewmembers should feel obligated to mention their own personal psychological stress or physical problems to other crewmembers before and during a mission.

"The pilot-in-command's responsibilities include coordination of inflight crewchief responsibilities."

"The pilot-in-command should use his crew to help him maintain situation awareness."

2) **Shared Leadership** - an attitude toward the appropriateness of sharing responsibility for leadership. Example items are:

"When joining a unit, a new crewmember should not offer suggestions or opinions unless asked." (negative response)

"Pilots-in-command who accept and implement suggestions from the crew are lessening their stature and reducing their authority." (negative response)

"The pilot-in-command should seek advice from crewmembers in updating mission plans."

3) **Recognition of Stressor Effects** - an attitude accepting that human performance is affected by external events and allowance must be made for changed performance. Example items are:

"Even when fatigued, I perform effectively during most critical flight maneuvers." (negative response)

"Most crewmembers can leave personal problems behind when flying a mission." (negative response)

"My decision making is as good in emergencies as in routine situations." (negative response)

Upon inspection, linkages were developed between the "logical" (Table 2.3-1) and the "factor" scales (Table 2.5-3). As will be seen in Sections 6 - 9, there is also some empirical evidence that justifies the relationships depicted in Table 2.5-3.

Table 2.5-3
Linkage between the Army CMAQ "Logical" and "Factor" Scales

"Logical" Scale	"equals"	"Factor" Scale
Values Teamwork	=	Shared Leadership
Crew Fallibility	=	Recognition of Stressor Effects
Give/Get Information	=	Communication & Coordination
Provide/Accept Help	=	Communication & Coordination

After developing the "factor" scales, scale and subscale statistics and reliability coefficients were computed. The results are presented in Table 2.5-4. Of note is that the "factor" scales for the Army CMAQ yielded higher reliability coefficients than both the NASA/UT CMAQ, which utilized a much larger sample but fewer items for each of the subscales, and the 45-item Army CMAQ "logical" scales.

Table 2.5-4
Comparative Scale Reliability Statistics for the Army CMAQ Using "Factor" Scales
(n=80)

Scale Name	# of Items	Avg. Item Mean	Scale S.D.	Reliabilities ** 1	2	3
1) Comm. & Coor.	17	5.90	.45	.77	.77	.61
2) Shared Leadership	11	5.69	.61	.75	.80	.54
3) Stressor Effects	6	4.43	.96	.67	.69	.49
4) Total (34 Items)	34	5.57	.43	.81	.85	.68

** Reliabilities:
1 = Cronbach's Alpha (n=80)
2 = Cronbach's Alpha (n=40, testbed aviators)
3 = Split-Half (odd-even) (n=80)

Finally, a correlation matrix (Table 2.5-5) was generated to show the relationship among the "factor" scales. Note that the "factor" subscale intercorrelations are generally lower than those of the "logical" subscale correlations shown in Table 2.4-4.

Table 2.5-5
Army CMAQ "Factor" Subscale Correlations
(n=80)

Scale Name	Total	Comm. & Coor.	Shared Leadership	Stressor Effects
Total (34 items)	---			
Comm. & Coor.	.72	---		
Shared Leadership	.82	.37	---	
Stressor Effects	.60	.05	.38	---

2.6 Comparison of Army and Civilian CMAQ Responses

In an article discussing the relationship between attitudes and performance, the NASA/UT Crew Performance Project (Helmreich et al., 1986) described the responses of "superior" (as rated by Check Airmen) commercial aviators to selected CMAQ items. NASA/UT found that, in general, superior aviators tend to hold similar attitudes regarding cockpit resource management and aircrew coordination. DRC/ARIARDA was also interested in determining if 1) Army aviators in the Fort Campbell sample were similar or dissimilar to the commercial aviators described by NASA/UT, and 2) if the CMAQ items differentiated between "good" and "poor" aviators. That

is to say, in relation to the second question, could a high or low quality Army aviator be described by attitude scores as obtained through the Army CMAQ.

To determine if such a description was possible, Army aviators were separated into high and low performance groups based on their scores on either of two measures:

- o Testbed aviators were placed into high or low groups based on their overall performance on the ATM tasks (high or low "performers"),

- o Aviators participating in the mass administration of the Army CMAQ in May 1990 were placed into high or low groups based on their "quality" ratings assigned by the unit IP (high or low "quality").

Tables 2.6-1 and 2.6-2 are frequency tables showing how Army aviators scored with respect to the two above mentioned measures. After inspecting the frequency tables, the aviators were divided into high and low "performance" or "quality" groups as indicated in the Tables. The "quality" ratings given to the May 1990 group were arrived at through the use of the "Experimental Ratings of Aviator Qualities" form (Appendix A.4). For ease of understanding and to make desired correlations positive, the "quality" ratings were recoded so that a rating of 3 was high and a rating of 1 was low. Of the 80 Fort Campbell aviators participating in the May 1990 administration of the Army CMAQ, 58 received "quality" ratings. Reliability (Cronbach's Alpha) of the quality ratings was computed and determined to be .82.

Table 2.6-1
Mean Scale Scores on ATM Task Performance and Division of Testbed Aviators into High and Low Performing Groups
(n=40)

Scale Score	Frequency	Percent	
1.62	2	5	Low "performers"
1.69	2	5	
1.72	2	5	
2.04	2	5	
2.15	2	5	
2.21	2	5	
2.22	2	5	
2.25	2	5	
2.28	2	5	
2.30	2	5	
2.38	2	5	
2.43	2	5	
2.46	2	5	
2.52	2	5	
2.69	2	5	
2.77	2	5	High "performers"
2.91	2	5	
2.96	2	5	
3.00	2	5	
3.08	2	5	
TOTAL	40		

Table 2.6-2
Mean Scores on "Quality" Ratings and Division of May 90 Group into High and Low Quality Groups
(n=58)

Mean Score	Frequency	Percent	
1.00	3	5	Low "quality"
1.25	5	9	
1.50	6	10	
1.75	7	12	
2.00	14	24	
2.25	10	17	
2.50	4	7	High "quality"
2.75	3	5	
3.00	6	10	
TOTAL	58		

Table 2.6-3 shows a CMAQ statement, the direction of agreement or disagreement of the commercial aviators, the mean item response for the entire sample taking the Army CMAQ, means for high and low "performing" testbed aviators, and means for high and low "quality" rated May 90 aviators. The Table covers only the 13 CMAQ items common to both the NASA/UT and the DRC/ARIARDA studies. Significant differences in means are noted with asterisks. Differences in direction, i.e., agree vs. disagree between commercial and Army responses are noted with plus signs.

Item numbers in Table 2.6-3 are ordered in the manner presented in the Helmreich et al. (1986) article and do not correspond to Army CMAQ item numbering. The actual item numbers from the Army CMAQ are C21, C13, C8, C9, C14, C11, C10, C2, C42, C43, C16, C44, and C19, translated into item numbers 1 through 13 respectively. After each item is a C## indicating the item number as it appeared on the Army CMAQ (NASA/UT CMAQ items 10 and 15 have no corresponding Army CMAQ statement).

Table 2.6-3
Comparison of High and Low Performer Aviators
on Selected CMAQ Items

Question:	NASA/UT Superior Rating	All Cases (n=168)	High ATM (n=10)	Low ATM (n=10)	High Qlty (n=13)	Low Qlty (n=21)
1. My decision-making ability is as good in emergencies as in routine mission situations. (C21)+	Disagree	++ 4.54	5.37	4.75	5.38	4.67
2. Pilots-in-command should encourage pilots and crew chiefs to question procedures and flight profile deviations during normal flight operations and in emergencies. (C13)	Agree	5.44	5.62	6.00	5.54	5.05
3. Crewmembers should be aware of and sensitive to the personal problems of other crewmembers. (C8)	Agree	5.76	6.00	5.62	6.14	5.71
4. The pilot-in-command, time and situation permitting, should take control and fly the aircraft in all emergency and non-standard situations. (C9)	Agree	++ 3.70	3.88	3.12	4.08	3.71
5. There are no circumstances where the pilot should take the aircraft controls without being directed to do so by the pilot-in-command. (C14)	Disagree	2.35	2.50	2.50	3.54 **	2.28
6. Pilots and other crewmembers should not question the decisions and actions of the pilot-in-command except where these actions obviously threaten the safety of the flight (C11)	Disagree	3.17	3.75	3.00	4.00	3.05
7. The pilot flying the aircraft should verbalize plans for procedures or maneuvers and should be sure that the information is understood and acknowledged by crewmembers affected. (C10)	Agree	6.11	6.25	6.25	6.23	6.00
8. Crewmembers should feel obligated to mention their own psychological stress or physical problems to other crewmembers before or during a mission. (C2)	Agree	5.74	5.62	5.12	5.77	5.14
9. Pilots in command should employ the same style of management in all situations and with all crewmembers. (C42)	Disagree	2.72	2.50	3.00	2.92	2.57
10. Pilots-in-command instructions to other crewmembers should be general and non-specific so that each individual can practice self-management and can develop individual skills. (C43)	Disagree	2.83	2.62	3.00	2.92	2.95
11. Training is one of the pilot-in-command's important responsibilities. (C16)	Agree	6.12	6.37 *	5.50	6.62	6.38

Table 2.6-3 (Cont.)

Question	NASA/UT Superior Rating	All Cases (n=168)	High ATM (n=10)	Low ATM (n=10)	High Qlty (n=13)	Low Qlty (n=21)
12. A relaxed attitude is essential to maintaining a cooperative and harmonious cockpit. (C44)	Agree	5.29	6.12***	4.75	5.23	5.67
13. The pilot-in-command's responsibilities include coordination of inflight crew chief activities. (C19)	Agree	6.16	6.12	6.25	6.46	6.19

+ C## denotes corresponding Army CMAQ item number.
++ Army and Civilian differ on this item.
*** $p < .01$, ** $p < .05$, * $p < .10$

In general, it was found that Army aviators have ratings similar to the NASA/UT commercial aviators. Furthermore, the differences between the high and low groups of Army aviators was generally in the expected direction. Were the Army sample larger, it might have been possible to obtain additional significant differences between the means of the high and low groups. It may be, however, that the lack of significance could also be due to a lack of power of the CMAQ to discriminate between "good" and "poor" Army pilots. Nevertheless, because of the small sample size, these results must be considered exploratory and therefore subject to further examination. For these same reasons, i.e., small sample and exploratory research, the typical test of significance was relaxed from .05 to .10.

At this point, explanations as to several responses are in order. In response to Statement 1, "My decision-making ability is as good in emergencies as in routine mission situations," Army aviators appear to differ from commercial aviators. The difference is thought to be due to two reasons. First, DRC was told by the IP-raters and I/Os at Ft. Campbell that Army aviators are taught that in emergency situations their abilities are heightened. However, this notion is only partially correct. Increased adrenaline heightens attention, strength, reaction speed, etc., but it also has the undesirable effect of focusing attention. Focusing, or "tunnel vision," does not enhance decision making ability. Secondly, Army aviators are taught to fly under adverse, dangerous (wartime) conditions. The objective of Army aviation missions is necessarily twofold: safety <u>and</u> mission accomplishment -- a dichotomy requiring careful balance and a willingness to take calculated risks not expected of commercial aviators. Commercial aviators operate under different constraints, i.e., safety is the primary consideration; of secondary importance is the delivery of passengers or freight. Consequently, the Army aviator is perhaps more likely to believe that his or her flying abilities are equal during both emergency situations and routine missions.

In response to Statement 4, "The pilot-in-command, time and situation permitting, should take control and fly the aircraft in all emergency and non-standard situations," the Army statistical means are in contrast to the commercial aviators. One reason for this is that AR 95-1 dictates that the pilot in command will be given absolute authority in the cockpit. The high "quality" group is, however, slightly in *agreement* with the statement. Both the groupings ("performers" and "quality") show separation in the desired direction in terms of the principles of aircrew

coordination. Were there a larger sample of Army aviators, it might be found high "performers" or high "quality" aviators align more closely with the "superior" commercial aviators, AR 95-1 notwithstanding.

In response to Statement 5, "There are no circumstances where the pilot should take the aircraft controls without being directed to do so by the pilot-in-command," Army aviators felt similarly to commercial aviators. However, there appeared a significant difference in means for the high and low "quality" aviators. Although the high "quality" Army aviators disagree with this statement, the low "quality" aviators disagree with it even more. This is contrary to what was expected and a good explanation for the significant difference is not available.

Army responses to Statement 11, "Training is one of the pilot-in-command's important responsibilities," and Statement 12, "A relaxed attitude is essential to maintaining a cooperative and harmonious cockpit," are in a similar direction to those of the commercial aviators. Additionally, agreement with the statements is significantly stronger among the high performer testbed aviators than the low performers. On these two items (11 and 12), DRC/ARIARDA data shows interesting parallels between Army and commercial aviators in that 1) Army aviators hold the same values as commercial aviators, and 2) there is a difference in attitude reflected on these items between high and low "performers."

Section 3.0
Properties of the ACE Checklist

3.1 General

Scales and scale scores were created for the ACE Checklist. The data collected at Ft. Campbell were based on the first use of the ACE Checklist, the initial version of which is at Appendix A.2. Frequency distributions were developed for each ACE Checklist item; and item analyses were performed for each of the six derived ACE Checklist scales. Frequency distributions and scale construction are further discussed below.

3.2 Frequency Distribution

Appendix C contains frequency distributions for the ACE Checklist items. [Note: ACE Checklist items 1-19 are referred to sequentially as A1 to A19.]

Due to pre-testbed training to establish interrater reliability, the participating IPs were clearly able to differentiate aircrew performance in terms of the behavioral anchors associated with each ACE Checklist item. The effectiveness of such training was demonstrated quantitatively by the raters availing themselves of the entire seven-point scale. As expected, ratings were generally in the lower half of the rating scale since the Fort Campbell aircrews were not given aircrew coordination training prior to the simulator mission.

Qualitatively, during testbed debriefings, the IPs unanimously attested to the ease of use of the ACE Checklist and the content validity of the instrument. They suggested some fine-tuning of the training, e.g., emphasize that ACE items 18 (Management of abnormal or emergency situation) and 19 (Conflict resolution) are optional. One instance which attests to the effectiveness of the training in the use of the ACE was exemplified by an IP-rater who rapidly recognized a return to previously used "norm-referenced" ratings versus the "criterion-referenced" ratings required for the testbed. He was able to correct his ratings to reflect the method taught during the pre-testbed training.

Examples of other IP-rater comments regarding the ACE Checklist were "Anchors were helpful, well-written, worked fine, very easy to use." Another IP-rater stated that "The wording of the anchors is realistic - very good...They are good descriptions. Nice spread. Enough room for judgements." The third IP-rater stated that "The seven-point scale worked fine ... the anchors were very helpful, absolutely."

3.3 Scales and Scale Construction

The 16 aircrew coordination-related items and three overall mission performance and workload items were used to derive the six ACE Checklist scales. For purposes of the testbed data analysis, Item #17 (Overall Workload) was excluded because it was considered external to crew control and, in the case of the Fort Campbell testbed, all crews were required to fly a

standardized mission scenario. The derivation of the ACE subscale definitions is explained in the Development of Measures technical report; they are part of the Resource Integration for Crewed Systems (RICS) Model developed by DRC for ARIARDA during the initial stages of the current project. The scale definitions are summarized in Table 3.3-1.

Table 3.3-1
ACE Checklist Scale Definitions

Scale Name	Scale Definition
1) Total ACE	All 16 aircrew coordination-related items on the Checklist.
2) Establish/maintain team relationships	Establish and maintain interpersonal relationships to create and maintain a harmonious team atmosphere and to execute mission objectives.
3) Cross monitoring of crew performance	Check each other's actions for possible errors.
4) Mission Information Exchange	Establish and maintain the same mission plan and a common frame of reference within each crewmember's mind in as much detail as possible. Expose the decision-maker to the full range of action options available at each important decision point.
5) Establish/maintain reasonable workload levels	Allocate workload in a reasonable manner across crewmembers.
6) Global performance	Global judgements of crew technical and resource management effectiveness.

During the development of the ACE Checklist, each item was logically placed into one of five behavioral domains. In the initial construction of the ACE subscales, ACE item #1 was placed into more than one domain (see Table 5.2-1 in the Development of Measures technical report). As discussed previously in relation to the Army CMAQ, for purposes of the data analysis it was necessary to make the subscales distinct to ensure that the correlations and regressions utilizing the subscales were interpretable. Consequently, Item #1 was placed under the "Establish/Maintain Team Relationships" behavioral domain. Placement of the items uniquely within each behavioral

domain is presented in Table 3.3-2. A sixth domain, which is a global rating comprising the overall technical proficiency and crew effectiveness dimensions, is also included in Table 3.3-2.

Table 3.3-2
Placement of ACE Checklist Items Within Behavioral Domains

Scale (Domain) Name	ACE Item Numbers
1) Total	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 13, 14, 18, 19
2) Establish/maintain team relationships	1, 9, 18, 19
3) Cross monitoring of crew performance	7, 8
4) Mission Information Exchange	2, 3, 4, 5, 6, 10
5) Establish/maintain reasonable workload levels	11, 12, 13, 14
6) Global Performance	15, 16

All ACE items were answered using a 7-point scale ranging from Very Poor (value = 1) to Superior (value = 7). Results of the reliability analyses (Cronbach's Alpha) performed on each of the six scales are presented in Table 3.3-3, together with the average item and scale scores. A correlation matrix computed for the six ACE Checklist scales is presented in Table 3.3-4.

Table 3.3-3
Cronbach's Alpha and Scale Scores for the ACE Checklist Scales
(n=20)

Scale Name	Number of Items	Cronbach's Alpha	Avg. Item Score	Scale S.D.
1) Total	16	.93	3.30	.73
2) Establish/maintain team relationships	4	.66	3.59	.78
3) Cross monitoring of crew performance	2	.69	3.28	.98
4) Mission Information Exchange	6	.89	3.15	.76
5) Establish/maintain reasonable workload levels	4	.83	3.26	.86
6) Global performance	2	.90	3.28	.98

Table 3.3-4
Correlations Between ACE Scales

	Total	Team Rels	Cross Monitor	Info Exchange	Workload Mgt.	Overall Perf.
Total	---					
Team Rels.	.90	---				
Cross Monitor	.86	.74	---			
Info Exchange	.91	.73	.76	---		
Workload Mgt.	.87	.75	.66	.67	---	
Overall Perf.	.89	.81	.75	.76	.85	---

Subscale reliabilities (internal consistency as measured by Cronbach's Alpha) for the ACE are high; reliability for the entire instrument is exceptionally high. Furthermore, the inter-correlations among the subscales were also very high. In summary, crews rated as high or low tended to be consistently rated as such across the items and across the subscales.

3.4 ACE Checklist Factor Analysis

A factor analysis was performed on the ACE checklist data to determine any underlying components of the measure. An unconstrained varimax rotation factor analysis yielded a four factor model. Upon inspection, the fourth factor provided results that could not be meaningfully interpreted. It was determined that a simpler, three-factor model might be more understandable. Thus, the factor analysis was constrained to three factors and the resultant data were interpretable and reasonably labeled. The rotated (varimax) factor matrix converged in 7 iterations with 72.5% of the variance explained. Table 3.4-1 shows the factor loadings for the three factor model. Note that A1 through A19 correspond to the ACE Checklist item numbers 1-19.

As depicted by Table 3.4-1, the three factors were similar to the previously defined ACE subscales. Factor 1 was determined to be an indicator of communication and group climate; Factor 2 was presumed to be an indicator of workload distribution and performance management; while Factor 3 appeared to be best explained as indicating cross monitoring by crewmembers.

Table 3.4-1
Factor Analysis Results
for the ACE Checklist
(n=20)

ACE Item #+	FACTOR 1 (Communication & Grp Climate)	FACTOR 2 (Workload & Perf. Mgt.)	FACTOR 3 (Cross Monitor)
A1	.11125	.40173	.51078 *
A2	.52846 *	.42282	.57056
A3	.69440 *	-.04313	.63908
A4	.70121 *	.02953	.34031
A5	.71185 *	.46635	.07074
A6	.67423 *	.14969	.13009
A7	.48828 *	.47881	.20985
A8	.56907	.15701	.65959 *
A9	.80547 *	.18787	.06974
A10	.49472	.58456 *	.36848
A11	.08832	.86557 *	.25846
A12	.02888	.75195 *	.32069
A13	.06652	.27261	.90594 *
A14	.30229	.25411	.84659 *
A15	.33973	.71600 *	.38310
A16	.44989	.61096 *	.56115
A18	.27158	.86927 *	-.04764
A19	.61267 *	.46395	.28839

* "Best Loading" determined by:
1) factor loading and
2) if an item loaded closely on two factors, it was logically placed.

\+ ACE Items # A1 to A19 are ACE item numbers 1 to 19.

Further use of the ACE "factor analytic" scales was rejected for several reasons:

1) The factors derived from the factor analysis were similar to the logical scales constructed and discussed in the Development of Measures technical report.

2) Results of any factor analysis from a sample as small as the testbed sample must be viewed with caution. When the Army CMAQ "factor" scales were created, the NASA/UT (Gregorich, et al. 1990) study was available in the literature. This study provided sufficient corroborating evidence from a much larger sample that the DRC/ARIARDA CMAQ "factor" scales were robust. Furthermore, Gregorich (personal communication, 1991) stated that when NASA/UT performed a factor analysis on the Line/LOFT Worksheet (an instrument similar to the ACE

Checklist), one predominant factor was developed together with a second weaker one. The first factor was described basically as communication and interpersonal relationships; the second was described as task enactment. According to Gregorich, NASA/UT had a confounding problem because of a lack of rater-independence. As a result of the referenced communication, it was agreed that while it is likely that there is an underlying structure to the ACE data, it cannot be detected given the small sample size and lack of any corroborating evidence.

3) The underlying factor structure of the Army's ACE data may, in fact, be quite different from the NASA/UT data, simply because commercial airline crews operate in a more proceduralized, predictable environment in terms of cockpit communications and task distribution. Given the Army's widely varying mission requirements, thus forcing an *ad hoc* approach to many situations, it is reasonable that cockpit communication and workload distribution show up as important dimensions.

4) There was no improvement in depicting scale relationships through the use of the ACE factor analytic scales. The properties of the ACE "factor analytic" scales were investigated in a fashion similar to the treatment of the Army CMAQ "factor" scales, i.e., analyses were conducted using the ACE "factors" to determine if there were improvements in the correlation coefficients with external variables. Results showed that, as compared to the ACE "logic-based" scales, the ACE "factor analytic" scales yielded virtually no improvements in depicting relationships between the ACE and external variables.

5) There was only a small gain in the reliability coefficients comparing the ACE "logic-based" and "factor analytic" scales. The ACE "logic-based" scales had previously shown themselves to have high reliability coefficients (while the Army CMAQ "logical" scales did not). Reliability analysis of the ACE "factor analytic" scales revealed Alpha coefficients for Factors 1, 2, and 3 as .93, .90, and .91, respectively. While these coefficients are better than those for the ACE "logic-based" scales, the "logic-based" scale reliability coefficients had revealed themselves to be well within the range of acceptability.

In summary, because a larger sample was not available, corroborating evidence of the stability of the ACE "factor analytic" scales could not be shown, and because there was no marked improvement in correlations with external variables, it was determined that no compelling reason existed to incorporate the ACE "factor analytic" scales into subseqeunt analyses. Consequently, the "logic-based" scales have been used in this analysis.

Section 4.0
Properties of the Revised ATM Tasks

4.1 General

Scales and scale scores were created for the revised Aircrew Training Manual (ATM) Tasks. The data collected at Fort Campbell were based on the first use of the revised ATM Tasks and the Modified Grade Slips. The Modified Grade Slips developed to capture performance data comprising both technical and aircrew coordination components can be seen in Appendix A.3. Frequency distributions were developed for each Modified Grade Slip item; and item analyses were performed for each of the derived ATM scales. Frequency distributions and scale construction are further discussed below.

4.2 Frequency Distribution

Appendix D contains frequency distributions for the Revised ATM Task items. [Note: The Revised ATM Tasks are referred to as T#### where #### represents the four digit sequence number of the task in TC 1-212, the ATM for the UH-60A.] The frequency distribution tables for the ATM Tasks are arranged in task numeric order, low to high; and, since only those tasks included in the standardized scenario developed for the testbed were rated, gaps in the numerical order of the ATM frequency tables result.

At this point it is necessary to explain the methods used for the selection of ATM Tasks to be included in the testbed. For those ATM tasks having logically evident aircrew coordination considerations, an *a priori* method of selection was used; e.g., Task 1001 (VFR Flight Planning) and Task 1071 (Aircrew Coordination). One other ATM task identified *a priori*, but not graded during the testbed, was 1002 (IFR Flight Planning). This resulted in two ATM Tasks being rated during the testbed. Other ATM tasks appearing in the frequency tables which have aircrew coordination considerations were selected based on accident data obtained from the Army Safety Management Information System (ASMIS). By this method, if an ATM task was identified as being performed immediately prior to the emergency situation and resulted in either five Class A accidents, or a total of ten Class A, B, and C accidents, then it was selected for rewrite to insert critical aircrew coordination requirements identified during accident investigations as either absent or lacking. This process resulted in the selection of an additional 12 ATM Tasks for rewrite, 11 of which were rated during the testbed. Thus there was a total of 13 aircrew coordination-related ATM Tasks used in the testbed. The remaining 16 ATM Tasks of the 29 in the frequency tables were included to obtain non-aircrew coordination-related performance data and to enhance reliability of the performance measures.

Unlike the other frequency tables in Appendix D, Table #1 (BIGRADE) relates to the global grade assigned by the IP to the crew after considering both the technical and the aircrew coordination components of the rated tasks. For the testbed, a departure from the normal Annual Proficiency and Readiness Test (APART) rating procedure was made. Normally, using the standard field rating system of satisfactory or unsatisfactory, failure of any one task during the

APART flight evaluation would result in an unsatisfactory grade for the flight. In that the testbed grading system was based on the academic grading system using the letters A, B, C, and U, IPs were asked to deviate from the field grading system by not using the automatic unsatisfactory rating and to give a letter grade to the flight which best reflected overall performance. Table #1 reflects this grading technique.

As with the ACE Checklist observation on the effectiveness of pre-testbed evaluator training, full use of the entire scoring range of A thru U was made by the IPs. Of particular note were the comments made by IPs during the testbed debriefings which indicated that they could no longer evaluate unit aviators in accordance with the old individually-based standards; they would henceforth incorporate aircrew coordination considerations to determine aviator and aircrew proficiency. One IP stated that the revised ATM Tasks were of great value. He said, "It makes the tasks definitive so aircrew coordination insertions and additions are in the right place and appropriate."

4.3 Scales and Scale Construction

Twenty-nine ATM Task items were used to derive two ATM scales. The first scale includes all ATM Tasks, the second includes only the revised, aircrew coordination-related ATM Tasks. As is evident through inspection of the frequency tables in Appendix D, there was a "missing data" problem; i.e., for many of the Tasks, only a subset of the testbed aircrews received ratings. Data analysis for this project was accomplished using SPSS-PC. Due to the manner in which SPSS-PC operates, Cronbach's Alpha can be computed only for scales comprising items having a complete set of responses; i.e., if one case (testbed aircrew) has a "missing" Task, then that case is eliminated from the scale reliability analysis. Therefore, scale reliability was calculated using a two-step method: (1) Cronbach's Alpha was calculated on those items having a complete set of responses, and (2) the Spearman-Brown prophecy formula was applied to determine the reliability for the lengthened test.

The Spearman-Brown prophecy formula is used to estimate the reliability of a new test if the length of the original test is changed. The only assumption in the formula is that the additional test items have qualities similar to the original items. The Spearman-Brown prophecy formula is expressed as:

$$\text{Reliability of lengthened test} = \frac{kr}{1 + [(k-1)r]}$$

Where, k is the changed test length
r is the reliability of the original test

Reliability of the ATM scales was very good. Of the 29 ATM Tasks (items) included in the standardized testbed mission scenario, 19 had complete data sets. Cronbach's Alpha for the 19 items was computed as .85. Applying the Spearman-Brown prophecy formula, the reliability for the 29 items is estimated to be .90.

Of the 15 revised ATM Tasks, 13 received ratings during the testbed with 10 items having complete data sets. Cronbach's Alpha for the 10 items was computed as .79. Applying the Spearman-Brown prophecy formula, the reliability for the 13 items used in the testbed is estimated to be .83. For the 15-item scale, reliability is estimated to be .85.

IP-raters employed the A, B, C, or U scoring method to rate each of the ATM Tasks. These scores were converted to a four point scale with A = 4, B = 3, C = 2, and U = 1. Scale scores for the 29 ATM Tasks and the 13 aircrew coordination-related ATM Tasks were computed using the average item score as the metric. Average item score for the 29 ATM Tasks was 2.39 (S.D.=.42); average item score for the 13 aircrew coordination-related ATM Tasks was 2.48 (S.D.=.47).

Table 4.3-1 presents the correlations among the 29 item scale (All ATM Tasks); the 13 item aircrew coordination-related scale (AC Tasks); the 12 item scale consisting of the aircrew coordination-related items less ATM Task 1071 (AC Tasks minus Task 1071); the single summary grade for the tasks (Overall Grade - "BIGRADE" in the Appendix D frequency table); and ATM Task 1071.

Table 4.3-1
Modified Gradeslip/ATM
Subscale Correlations
(n=20)

	All ATM Tasks	AC Tasks	AC Tasks Minus Task 1071	Overall Grade	Task 1071
All ATM Tasks	---				
AC Tasks	.93	---			
AC Tasks minus Task 1071	.92	.99	---		
Overall Grade	.85	.86	.85	---	
Task 1071	.65	.66	.53	.59	---

The statistical properties associated with the ATM Task ratings show the ratings to be remarkably consistent. High or low performers tended to be consistently rated as such across the items and across the subscales. To be sure, the Project benefitted from the thorough familiarity the IP-raters have with the Gradeslips and their well-practiced skills of rating aviator performance on the ATM Tasks. However, as mentioned above, the IP-raters stated that using the ATM Tasks in their revised format was easy and that the revisions had a great deal of content validity.

4.4 Use of Task 1071 Standards

ATM Task 1071, "Perform Aircrew Coordination," was revised extensively from its original version to incorporate the DRC/ARIARDA view of essential aircrew coordination activities. The revision of Task 1071 included eleven (11) Standards associated with successful ATM Task performance (Table 4.4-1).

Table 4.4-1
Task 1071 Standards

Standard #	Text
S1.	All crewmembers actively participate in the preflight/inflight mission planning.
S2.	A detailed aircrew briefing is accomplished prior to takeoff.
S3.	Each crewmember acknowledges his role, responsibilities, and tasks for the entire mission.
S4.	Two-way communication is established and maintained using standard phraseology and visual signals.
S5.	Conflicts are encouraged and judiciously resolved in an atmosphere of mutual respect.
S6.	All essential information is shared between crewmembers.
S7.	All crewmembers participate in the problem solving process.
S8.	Situational awareness is demonstrated at all times by each crewmember with respect to mission objectives, aircraft position, equipment status, environmental conditions, and personnel capabilities.
S9.	All crewmembers coordinate task execution to ensure that critical task timing and sequencing is achieved.
S10.	All crewmembers participate in the critique process by offering criticism in a constructive, supportive manner.
S11.	Crewmembers work smoothly as a team committed to safe, mission-oriented flying.

The 14 other aircrew coordination-related ATM Tasks revised for this Project included both Task-specific aircrew coordination activities (articulated in the Task Standards and Description)

and a Standard requiring, "Employ aircrew coordination techniques in accordance with Task 1071." IP-raters indicated during the post-testbed debrief that referencing Task 1071 Standards in other ATM Tasks "worked fine."

With respect to the use of the ATM Task 1071 Standards, when an aircrew was given a B, C, or U rating, IPs were required to provide two additional items of information. The first item indicated whether the rating was due predominantly to a deficiency related to flight *or* aircrew coordination skills. The second item, if the deficiency was aircrew coordination-related, specified which of the eleven Task 1071 Standards was not accomplished. Table 4.4-2 shows how the IPs used the eleven Task 1071 Standards across the 13 aircrew coordination-related ATM Tasks performed during the simulator scenario.

Table 4.4-2
Incidence of IP-Rater Use of Task 1071 Standards for Crew Coordination-Related Revised ATM Tasks

ATM Task#+	Task 1071 Standard:++ S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11
1001	3	6	4			3		1			
1007			3			2		3	1		2
1015											
1017			1	1		1		5			3
1028											
1031			1	3		6		7			3
1068	1			4		5	3	4	2		1
1071	5	4	5	10	2	13	2	6	2		3
1098			2	2		1		2			1
2009		1		3	1	3		4			2
2016			3	4		4		3	2		3
2081				7		5	1	3			2
2084						2		6	1		3
	--	--	--	--	--	--	--	--	--	--	--
Total	9	11	19	34	3	45	6	44	8	0	23

\+ ATM Task # refers the ATM Tasks found in Appendix A.3.
++ Task 1071 Standard S1 to S11 refer to the eleven standards listed in Table 4.4-1.

Task 1002 (Plan an IFR Flight) and Task 1053 (Perform Simulator Engine Failure at Altitude) are not reflected in Table 4.4-2 because they were not included in the standardized mission scenario. Only one crew was rated on Task 1015 (Perform Ground Taxi), and only three crews were rated on Task 1028 (Perform VMC Approach). No Task 1071 Standards are noted as deficient on Tasks 1015 and 1028 because deficiencies in performance on those two tasks were rated as flight skill-related and not aircrew coordination-related.

As the Table 4.4-2 demonstrates, Standard 6 was most frequently used, closely followed by Standard 8. One IP-rater commented that Standard 8 was "very well written." Other highly used Standards were 4, 3, 2, 1 and 9.

Standard 10 was not used because aircrews did not avail themselves of the opportunity to accomplish their own post-flight debriefing and there was little time during the simulator session to critique. Also, it is noted that there is no current ATM Task that covers the critique function (during or post-mission). Besides ATM Task 1071, DRC/ARIARDA has included statements covering the post-flight critique function in revised ATM Task 1098 (After Landing Tasks); however, this Task was not written into the scenario and, hence, was not graded. Also, in keeping with the lack of an ATM Task which would rate crew-initiated critique during simulated/actual missions, the Fort Campbell culture did not appear to embody this very important function.

During actual, non-simulated operations, a critique could take place post-flight, as well as during other appropriate times of an operation (for instance, during refueling). Field refueling might take 20 minutes whereas in the simulator, refueling takes about 20 seconds, thus negating this opportunity. Finally, critique does not appear to relate well to current ATM Task accomplishment. One IP-rater, while agreeing that the Standard is important, stated that under current doctrine, "Post-flight activities are not a part of ATM Tasks." The other two IP-raters agreed that the Standard was "Good," and indicated that it should be kept as part of Task 1071. One of the IP-raters stated that the Description section of Task 1071 helped him understand the importance of Standard 10.

Standard 5 was used on only 3 occasions, probably because there was little obvious discord within the crews. Furthermore, the draft Standard used in the testbed read "Conflicts are encouraged and judiciously resolved in an atmosphere of mutual respect." During the post-testbed IP debriefs it was found that the word "conflicts" is a stronger word to Army personnel than was thought. To the IP-raters, the word "conflicts" usually refers to a physical fight or military action. Realizing this, DRC recommends that the Standard include the phrase "Differences of opinion" instead of the word "Conflicts".

Standard 7 was used on only 6 occasions. It is supposed, as was postulated in the Development of Measures technical report, that problem solving is generally interpreted as analytical problem solving and there is little of that type of problem solving occurring aboard rotary-wing aircraft in a tightly coupled environment. Nevertheless, the IP-raters did use Standard 7 in an amount sufficient to warrant its remaining in the ATM revision; one IP stated that Standard 7 is "good, easily interpretable."

In summary, the Revised ATM Tasks and associated Gradeslips were found by the IP-raters to have high content validity, to be easy to use, and to be of value to the Army. Analysis of the data from the use of the instrument showed it to have very high reliability.

Section 5.0
Properties of the Performance Measures

A primary advantage of pursuing research within a simulator environment is the ability to standardize a mission across crews. During the testbed the same set of mission parameters confronted each of the twenty Fort Campbell testbed aircrews. As has been previously shown, performance within the standardized mission varied from crew to crew as measured by the IP-ratings given to crews on the ATM Tasks and the ACE Checklist. In addition to the IP-ratings used as behavioral measures, the ARIARDA research team was able to capture mission-related measures of performance. By using the controlled environment offered by the simulator, an "objective" comparison of crew performance in relation to utility helicopter-related performance outcomes can be made.

Only an overview of the performance variables will be presented in this Section. Much credit is due to personnel from Anacapa Sciences, Inc. who assiduously analyzed the videotapes of the missions to capture the performance variables. It is assumed that Anacapa has provided ARIARDA with a detailed report discussing the construction and properties of the performance variables. Table 5.0-1 shows the values of the performance variables developed by Anacapa used in the analyses; Table 5.0-2 contains brief definitions of each of the performance variables.

Table 5.0-1
Utility Helicopter-Related Performance
Variables Used in the Data Analyses

Crew#	Time Cross FLOT	Number of Flt. Dev's	% Time off Course	Within	# of Threat Encounters	Total Duration Encounters	Mean Duration	Duration of Longest Encounter	ILS Steps Correct	ILS % Correct
1	32.0	2	7.1	0	7	81	11.6	25	(7/11)	64
2	27.4	1	6.5	1	2	15	7.5	10	(3/12)	25
3	32.8	2	17.8	0	2	19	9.5	15	-	-
4	-	-	-	-	-	-	-	-	(12/12)	100
5	42.0	2	37.3	0	9	129	14.3	25	-	-
6	33.4	3	43.8	0	7	120	17.1	56	(9/11)	82
7	24.1	1	15.8	1	1	20	20.0	20	(12/12)	100
8	24.3	3	28.7	0	2	11	5.5	8	(9/11)	82
9	27.7	0	0.0	0	7	73	10.4	16	(12/12)	100
10	25.4	1	10.4	0	1	9	9.0	9	(7/11)	64
11	29.8	2	34.4	0	5	67	13.4	32	(10/12)	83
12	26.8	0	0.0	0	1	5	5.0	5	(11/12)	92
13	30.1	1	39.2	1	5	63	12.6	20	(8/12)	75
14	33.0	2	21.7	0	1	5	5.0	7	(10/11)	91
15	30.0	2	75.8	0	3	69	23.0	46	(8/11)	73
16	28.7	1	23.0	0	4	58	14.5	23	(11/12)	92
17	23.2	0	0.0	1	3	36	12.0	14	(9/12)	75
18	38.9	3	55.6	0	4	47	11.8	24	(11/12)	92
19	37.4	2	43.8	0	6	79	13.2	23	(11/12)	92
20	28.6	1	32.9	1	10	126	12.6	23	(11/12)	92

Note: Crew 3 mission aborted prior to ILS approach.
Crew 4 missing data due to a technical problem with the videotape.

Table 5.0-2
Brief Definitions of the Performance Variables

Variable	Definition
Crew #:	The sequential identification number of the testbed aircrew.
Time Cross FLOT	The amount of time, in minutes, an aircrew used during the tactical phase of the mission. Ideally, crews should have taken 24 minutes.
Number of Flt. Dev's:	The number of times an aircrew deviated from the planned flight path during the tactical phase of the mission by greater than 500 meters as a result of a navigation or crew coordination error.
% Time off Course:	The percent of time during the tactical phase of the mission that the crew was off course as a result of a navigation or crew coordination error.
Within:	Whether or not the aircrew performed Cross-FLOT operations within the allotted 24 minutes. A "1" means yes; a "0" means they did not.
# of Threat Encounters:	The number of times, during the tactical phase of the mission, that the helicopter was acquired by enemy radar.
Total Duration Encounters	The total time in seconds that the helicopter was acquired by enemy radar.
Mean Duration	The average time in seconds that the helicopter was acquired by enemy radar, including all events. Calculated by dividing the Total Duration Encounters by the # of Threat Encounters.
Duration of Longest Encounter	The duration of the single, longest encounter with enemy radar.
ILS Steps Correct	There were a possible twelve steps crews could perform during the instrument approach. The first number represents the number of steps taken correctly, the second number is the number of steps (of 12) for which we have data. Some crews have fewer than twelve steps due to "unknown" performance on certain steps.
ILS % Correct	The percentage of correct steps during the instrument approach.

Section 6.0
Relationships Among the Measures

6.1 Introduction

The data collected at Fort Campbell potentially contained relationships requiring further exploration. For example, it was hypothesized that a relationship existed between the attitudes held by Army pilots and their performance. The data allowed for this type of inquiry by regressing the attitude measure (Army CMAQ) with the performance measures. It was also hypothesized that relationships would exist among the behavior/performance measures, i.e., between the ACE Checklist, ATM Task performance, and the simulator performance variables.

The questions which the following Sections are designed to answer are listed here. The analyses used to answer the questions are contained in Sections 6 through 9. Summary answers are provided in Paragraph 10.10.

1. What is the relationship between the two measures of crew behavior (ACE Checklist and ATM Tasks)?

2. What is the relationship between crew coordination behaviors (ACE Checklist) and Mission Performance?

3. What is the relationship between crew behaviors (ATM Tasks) and Mission Performance?

4. What is the relationship between the combined effect of crew coordination behaviors (ACE Checklist + ATM Tasks) and Mission Performance?

5. Which organization of the Army CMAQ, "logical" or "factor," is better?

6. What *combination* of crewmember attitudes, as measured by the CMAQ, best demonstrates relationships between crew attitude and crew coordination behaviors/Mission Performance?

7. What is the relationship between crew coordination attitudes (Army CMAQ) and crew coordination behaviors (ACE Checklist)?

8. What is the relationship between crew coordination attitudes (Army CMAQ) and crew coordination behaviors (ATM Tasks)?

9. What is the relationship between crew coordination attitudes (Army CMAQ) and Mission Performance?

10. What is the relationship between the combined effect of crew coordination attitudes and behaviors (Army CMAQ + ACE Checklist + ATM Tasks) and Mission Performance?

Numerous equations developed for this analysis are presented in this Section and the three following. Each of these Sections contains a preface and a note as to its organization. An overview and a brief description of the Sections is as follows:

Section 6 · This Section describes the analyses conducted to determine the relationships among the measures. Results of analyses examining the relationships between the CMAQ "logical" scales and those of the behavior and performance measures are described.

Section 7 Investigations similar to those in Section 6, but utilizing the CMAQ "factor" subscales. Certain relationships; e.g., ACE → ATM, previously presented in Section 6 are omitted.

Section 8 The focus on the relationships among the measures is continued. However, in this Section, various combinations of an aircrew's, not the individual, Army CMAQ "logical" scores are used to develop the equations.

Section 9 Investigations similar to those in Section 8, but utilizing the CMAQ "factor" scales instead of the "logical" scales.

Each Section begins with a short explanation of the questions it attempts to answer, followed by an organizational chart. The chart summarizes all of the tables in the Section and provides a brief account of relevant conclusions. Following the organizational chart, regression equations are presented together with more in-depth comments supporting the summaries found within the organizational chart. Each Section concludes with an overview of the findings of that section, or in some cases, with a summary of the findings across two or more relevant sections. Finally, Section 10 presents a summary of the analyses presented in this report.

With respect to the sample sizes used to determine the relationships among the measures, it should be noted that they varied depending on the regression equation developed. Since 40 aviators participated in the Fort Campbell testbed, 40 Army CMAQs were available for use in the analysis; however, there were only 20 ACE Checklist, ATM Task (Modified Gradeslips) and simulator performance observations. In some instances, missing data further limited the available sample size for an equation. Therefore, although the Tables used in Sections 6 - 9 indicate a sample size of either "(n=20)" or "(n=40)," due to missing data this may not be precise for all equations. What is important to note is that when "(n=20)" is cited, the analysis is "crew-based;" when "(n=40)" is cited, the analysis is "individual-based."

Since the nature of this data analysis was exploratory and the sample size small, it was decided in many instances to relax the test of significance to .10. Tests of significance are noted in the text and/or in the Tables. In Sections 8 and 9, the criteria for F-to-enter and F-to-remove into

the regression equations were relaxed to allow meaningful stepwise regression equations to be developed. A further explanation of this manipulation is presented in Section 8.

In that a great number of variables are used in this and in the following Sections, Table 6.1-1 introduces the variable names and provides a brief description of them. Several additional variables, used to "weight" combinations of the PC and PI CMAQ scores, are introduced in Table 8.1-1.

Table 6.1-1
Names and Definitions of Variables Used in Regression Analyses for Sections 6, 7, 8, & 9

Source	Variable	Brief Description
Army CMAQ "Logical" Scales		
	TEAMCMAQ	Scale consisting of the seventeen CMAQ items relevant to Values Teamwork (#'s 1, 4, 5, 7, 8, 9, 15, 19, 22, 25, 26, 27, 29, 30, 42, 44, 45).
	CREWFAL	Scale consisting of the eleven CMAQ items relevant to Crew Fallibility (#'s 6, 11, 12, 14, 17, 18, 20, 21, 28, 38, 41).
	GIVEGET	Scale consisting of the ten CMAQ items relevant to Giving and Getting information (#'s 2, 10, 13, 23, 24, 31, 32, 33, 34, 43).
	HLPCMAQ	Scale consisting of the seven CMAQ items relevant to Providing and Accepting Help (#'s 3, 16, 35, 36, 37, 39, 40).
	CMQALL	Scale consisting of all 45 CMAQ items.
Army CMAQ "Factor" Scales		
	COMMCOR	Scale consisting of the seventeen CMAQ items relevant to Communication & Coordination (#'s 2, 6, 7, 8, 13, 15, 18, 19, 23, 28, 30, 31, 33, 36, 37, 40, 44).
	SHARLEAD	Scale consisting of the eleven CMAQ items relevant to Shared Leadership (#'s 14, 24, 26, 27, 32, 35, 38, 39, 42, 43, 45).
	STRESS	Scale consisting of the six CMAQ items relevant to Recognition of Stressor Effects (#'s 12, 20, 21, 22, 34, 41).
	CMAQ34	Scale consisting of all 34 CMAQ items included in the "factor" scales.

Table 6.1-1 (Cont.)

ACE Checklist	TEAMACE	Scale consisting of the four ACE items relevant to Establish/Maintain Team Relationships (#'s 1, 9, 18, 19).
	XMNITOR	Scale consisting of the two ACE items relevant to Cross Monitoring of Crew Performance (#'s 7, 8).
	INFOEXC	Scale consisting of the six ACE items relevant to Mission Information Exchange (#'s 2, 3, 4, 5, 6, 10).
	WORKMNG	Scale consisting of the four ACE items relevant to the Establish/Maintain Reasonable Workload Levels (#'s 11, 12, 13, 14).
	ACEALL	Scale consisting of sixteen ACE items (#'s 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 18, 19).
	GLOBAL	A global performance measure consisting of two ACE (#'s 15 and 16).
Graded ATM Tasks	ATMALL	Scale consisting of the 29 ATM Tasks evaluated during the Ft. Campbell testbed.
	ATM_13	Scale consisting of the 13 aircrew coordination-related ATM Tasks.
	ATM_12	Scale consisting of the aircrew coordination-related ATM_13 Scale less Task 1071.
	BIGRADE	Overall grade assigned to each aircrew by the IP.
	TASK1071	Grade assigned to each aircrew on ATM Task 1071.
Simulator Performance Variables	NAVTIME	Length of tactical phase of flight, in minutes.
	DEVIATE#	Number of deviations from planned course during tactical phase of flight.
	%OFFCOUR	Percent of time off planned course during tactical phase of flight.
	WITHIN	Mission flown within allotted time limit for Cross-FLOT operations.
	THRT#	Number of threat encounters during tactical phase of flight.
	THRTIME	Total duration of threat encounters during tactical phase of flight.

Table 6.1-1 (Cont.)

THRTMAX	Duration of longest threat encounter during tactical phase of flight.
MEANDUR	Mean duration of threat encounters during tactical phase of flight.
ILSRIGHT	Percentage of correct "steps" on the ILS approach.

To properly interpret the following correlations and regressions, it is important to note that a higher score is better for the ATM Task, ACE Checklist, and Army CMAQ scales, and the ILSRIGHT, and WITHIN variables. Conversely, a lower score is better for the NAVTIME, DEVIATE#, %OFFCOUR, THRT#, THRTIME, THRTMAX, and MEANDUR variables.

In the remainder of this Section, regression equations involving the ATM Task measures, the ACE Checklist measures, the CMAQ "logical" scales, and the simulator performance variables are presented. Table 6.1-2, shown below, is the organizational chart for this Section.

Table 6.1-2
Organizational Chart for Section 6

Analysis/Equation	Interpretation	Table(s)
6.2 Predict ATM performance using ACE scales	ACE scales are highly predictive of ATM performance	6.2-1, 6.2-2, 6.2-3
6.3 Predict ATM performance using CMAQ "logical" scales	CMAQ "logical" scales are not predictive of ATM performance. CMAQ appears to have a small (ns) effect on AC-related ATM tasks.	6.3-1
6.4 Predict ACE performance using CMAQ "logical" scales	CMAQ "logical" scales are not predictive of ACE performance	6.4-1
6.5 Predict ATM performance using CMAQ "logical" scales and ACE scales	More variance explained than either independent variable alone. CMAQ consistently drops from the stepwise equations.	6.5-1, 6.5-2, 6.5-3
6.6 Predict mission performance variables using ACE scales	ACE scales have moderate ability to predict mission performance variables. WORKMNG strongly affects navigation.	6.6-1, 6.6-2
6.7 Predict mission performance variables using CMAQ "logical" scales	CMAQ "logical" scales are not predictive of mission performance variables	6.7-1
6.8 Predict performance variables using CMAQ "logical" scales, ACE scales, and ATMALL	More variance explained than any independent variable alone. Various ACE scales and ATMALL are predictive of several mission performance variables. HLPCMAQ enters as a significant predictor variable.	6.8-1, 6.8-2
6.9 Predict performance variables using ATMALL, CMQALL, and ACEALL	A combination of ATMALL, CMQALL, and ACEALL are predictive of several performance variables; CMAQALL consistently drops from stepwise equations.	6.9-1, 6.9-2

6.2 Predict ATM Performance Using ACE Scales

Four of the six ACE subscales were forced into the regression equations to predict performance on five ATM measures. The ACEALL and GLOBAL subscales were not included in the equations. The ACEALL variable, if included, would have made the predictor variables dependent on one another. The GLOBAL variable was of limited interest because 1) the focus of the current analyses is on the four dimensions of aircrew coordination captured via the ACE Checklist; 2) the GLOBAL subscale was considered redundant to the ATM variable, BIGRADE; and 3) only one of the two items comprising the GLOBAL variable was related to aircrew coordination. The focus of these equations was to determine the predictive power of the ACE subscales on ATM Task performance. The five forced regression equations are at Table 6.2-1.

Table 6.2-1
Forced Regression of ACE Scales with ATM Measures*
(n=20)

Equation	Multiple R	% Variance
1.) ATMALL =.10 WORKMNG + .18 XMNITOR + (-.12) INFOEXC + .23 TEAMACE + 1.02	.77	60
2.) ATM_13 = .21 WORKMNG + .21 XMNITOR + (-.19) INFOEXC + .21 TEAMACE + .96	.81	66
3.) ATM_12 = .25 WORKMNG + .21 XMNITOR + (-.26) INFOEXC + .18 TEAMACE + 1.17	.79	62
4.) BIGRADE = .48 WORKMNG + .32 XMNITOR + (-.14) INFOEXC + .002 TEAMACE + .03	.76	58
5.) TASK1071 = (-.14) WORKMNG + .21 XMNITOR + . 46 INFOEXC + .41 TEAMACE + (-1.00)	.76	58

* In all equations, F is significant at the $p < .01$ level.

Table 6.2-1 demonstrates that the ACE scales are highly predictive of ATM performance. By entering the ACE variables into the equations in a stepwise manner, it was thought that the more predictive independent variables would be revealed. Table 6.2-2 shows these stepwise regression equations.

Table 6.2-2
Stepwise Regression of ACE Scales
with ATM Measures*
(n=20)

Equation	Multiple R	% Variance
1.) ATMALL = .39 TEAMACE + .97	.71	51
2.) ATM_13 = .44 TEAMACE + .90	.72	52
3.) ATM_12 = .38 WORKMNG + 1.28	.69	48
4.) BIGRADE = .64 WORKMNG + .12	.71	51
5.) TASK1071 = .88 INFOEXC + (-56)	.70	50

* In all equations, F is significant at the $p < .001$ level.

Only one independent measure entered each of the equations. WORKMNG is the single most influential attribute of graded performance on the 12 aircrew coordination-related ATM Tasks and BIGRADE. Likewise, TEAMACE best predicts overall ATM Task performance (ATMALL) and aircrew coordination-related ATM Tasks when Task 1071 is included in the scale (ATM_13). Furthermore, INFOEXC scale best predicts Task 1071 performance.

Next, the ACEALL measure (16 ACE items), was entered singly into forced regression equations of the five ATM measures. The results are shown at Table 6.2-3. F is significant at the $p < .001$ level in all equations.

Table 6.2-3
Forced Regression of ACEALL
with ATM Measures*
(n=20)

Equation	Multiple R	% Variance
1.) ATMALL = .42 ACEALL + 1.01	.71	50
2.) ATM_13 = .47 ACEALL + .91	.73	53
3.) ATM_12 = .42 ACEALL + 1.10	.66	44
4.) BIGRADE = .73 ACEALL + (-.20)	.69	48
5.) TASK1071 = .95 ACEALL + (-.93)	.73	53

* In all equations, F is significant at the $p < .001$ level.

Table 6.2-3 demonstrates that the ACEALL measure is a powerful predictor of ATM Task performance. In summary, the ACE subscales and ACEALL are very good predictors of ATM Task performance.

6.3 Predict ATM Performance Using the CMAQ "Logical" Scales

Regression equations were next calculated to determine the predictive ability of the Army CMAQ with respect to the ATM scales. The four CMAQ "logical" subscales (see Section 2.3 for discussion of scale development) were forced into regression equations of the five ATM measures. Since CMAQ ratings are individual-based (rated ATM performance is crew-based), all 40 cases were included in these analyses. The five equations are at Table 6.3-1.

Table 6.3-1
Forced Regression of CMAQ "Logical" Scales with ATM Measures*
(n=40)

Equation	Multiple R	% Variance
1.) ATMALL = (-.004) HLPCMAQ + .05 CREWFAL + .03 TEAMCMAQ + (-.09) GIVEGET + 2.52	.12	1
2.) ATM_13 = .008 HLPCMAQ + .18 CREWFAL + .04 TEAMCMAQ + (-.18) GIVEGET + 2.37	.25	6
3.) ATM_12 = .04 HLPCMAQ + .17 CREWFAL + .04 TEAMCMAQ + (-.22) GIVEGET + 2.51	.27	7
4.) BIGRADE = (-.11) HLPCMAQ + .25 CREWFAL + (-.06) TEAMCMAQ + (-.10) GIVEGET + 2.49	.18	3
5.) TASK1071 = (-.24) HLPCMAQ + .32 CREWFAL + (-.03) TEAMCMAQ + .21 GIVEGET + .99	.22	5

* In all equations, F is <u>not</u> significant at the $p < .05$ level.

Table 6.3-1 demonstrates that the CMAQ "logical" subscales do not have significant predictive power when entered onto the ATM measures. Upon closer inspection, it would appear that the CMAQ may have some small effect on the aircrew coordination-related ATM Tasks (specifically, ATM_13, ATM_12, and TASK1071); however, the effect is not statistically significant. Stepwise regression (with the probability of F-to-enter set at $p < .05$) using the Army CMAQ "logical" subscales resulted in no variables entering the equations.

6.4 Predict ACE Performance Using CMAQ "Logical" Scales

The four Army CMAQ "logical" subscales were forced into the regression equations to find their predictive power with respect to the six ACE subscales. The six equations developed are at Table 6.4-1.

Table 6.4-1
Forced Regression of CMAQ "Logical" Scales with ACE Measures*
(n=40)

Equation	Multiple R	% Variance
1.) ACEALL = (-.33) HLPCMAQ + .13 CREWFAL + .01 TEAMCMAQ + .10 GIVEGET + 3.86	.21	4
2.) TEAMACE = (-.21) HLPCMAQ + .06 CREWFAL + .05 TEAMCMAQ + (-.01) GIVEGET + 4.32	.14	2
3.) XMNITOR = (-.32) HLPCMAQ + (-.06) CREWFAL + .09 TEAMCMAQ + .05 GIVEGET + 4.69	.17	3
4.) INFOEXC = (-.53) HLPCMAQ + .16 CREWFAL + .006 TEAMCMAQ + .18 GIVEGET + 4.39	.32	10
5.) WORKMNG = (-.13) HLPCMAQ + .27 CREWFAL + (-.05) TEAMCMAQ + .13 GIVEGET + 2.17	.19	4
6.) GLOBAL =(-.36) HLPCMAQ + .15 CREWFAL + (-.22) TEAMCMAQ + .33 GIVEGET + 3.89	.18	3

* In all equations, F is <u>not</u> significant at the $p < .05$ level.

The Army CMAQ "logical" scales have little value in predicting either ACE Checklist (Table 6.4-1) or ATM Task (Table 6.3-1) scores. However, upon closer inspection of Table 6.4-1, it would appear that the CMAQ may have a small effect on INFOEXC; however, the effect is not statistically significant. Stepwise regression (with the probability of F-to-enter set at $p < .05$) using the Army CMAQ "logical" scales and the ACE subscales resulted in no variables entering the equations.

6.5 Predict ATM Performance Using CMAQ "Logical" Scales and ACE Scales

Table 6.5-1 shows the regression equations when the ACE and CMAQ subscales are used collectively for predicting ATM performance. As in Paragraphs 6.2 and 6.3, the ACEALL, GLOBAL, and CMQALL measures were not used in the analyses.

Table 6.5-1
Forced Regression of ACE Scales and CMAQ "Logical" Scales with ATM Measures*
(n=40)

Equation	Multiple R	% Variance
1.) ATMALL =.10 WORKMNG + .06 HLPCMAQ + .01 TEAMCMAQ + .04 CREWFAL + .18 XMNITOR + (-.09) GIVEGET + (-.11) INFOEXC + .23 TEAMACE + .97	.78	61
2.) ATM_13 =.19 WORKMNG + .05 HLPCMAQ + .02 TEAMCMAQ + .16 CREWFAL + .23 XMNITOR + (-.18) GIVEGET + (-.20) INFOEXC + .20 TEAMACE + .86	.84	71
3.) ATM_12 = .24 WORKMNG + .03 HLPCMAQ + .03 TEAMCMAQ + .15 CREWFAL + .23 XMNITOR + (-.22) GIVEGET + (-.27) INFOEXC + .17 TEAMACE + 1.36	.82	68
4.) BIGRADE =.48 WORKMNG + (-.03) HLPCMAQ + (-.07) TEAMCMAQ + .17 CREWFAL + .34 XMNITOR + (-.15) GIVEGET + (-.17) INFOEXC + (-.01) TEAMACE + .64	.77	60
5.) TASK1071 = (-.30) WORKMNG + .18 HLPCMAQ + (-.10) TEAMCMAQ + .31 CREWFAL + .28 XMNITOR + .14 GIVEGET + .52 INFOEXC + .48 TEAMACE + (-3.99)	.80	65

* In all equations, F is significant at the $p < .0001$ level.

Table 6.5-1 shows that when the ACE scales and CMAQ "logical" scales are combined, they have excellent predictive power of ATM performance. When Table 6.5-1 is compared to 6.2-1, it is apparent that the combination of the ACE and CMAQ subscales accounts for slightly more variance than the ACE subscales do alone. Interestingly, the aircrew coordination-related ATM scales; i.e., ATM_13, ATM_12, and Task 1071, appear to benefit most from adding the CMAQ scales to the equations. Consequently, it was thought that the more predictive measures would be revealed by entering the ACE and CMAQ variables into the equations in a stepwise manner. Table 6.5-2 shows these regression equations.

Table 6.5-2
Stepwise Regression of ACE Scales and CMAQ "Logical" Scales with ATM Measures*
(n=40)

Equation	Multiple R	% Variance
1.) ATMALL = .25 TEAMACE + .15 XMNITOR + .98	.75	57
2.) ATM_13 =.26 TEAMACE + .22 WORKMNG + .83	.77	59
3.) ATM_12 =.31 WORKMNG + .26 XMNITOR + (-.22) INFOEXC + 1.33	.77	59
4.) BIGRADE =.44 WORKMNG + .26 XMNITOR + (-.09)	.76	57
5.) TASK1071 =.55 INFOEXC + .44 TEAMACE + (-1.10)	.75	56

* In all equations, F is significant at the $p < .0001$ level.

While it was previously found that the CMAQ alone has little predictive value with respect to either the ACE Checklist or the ATM Tasks, when included with the ACE subscales, the CMAQ does influence the equations. For example, in Table 6.2-2, wherein the ACE subscales are entered stepwise into the equations, the only variable loading with ATM_12, the dependent variable, is WORKMNG. In Table 6.5-2, equation #3, while WORKMNG still enters first in the equation, it is apparent that XMNITOR and INFOEXC are also important factors. In Table 6.2-2 only three of the four ACE scales enter the equation; however, in Table 6.5-2, when the attitude subscales are allowed to influence the equations, all four ACE subscales enter at least two of the equations.

Next, the two overall measures, CMQALL and ACEALL, were forced into the regression equations to predict ATM Task performance. These equations can be seen in Table 6.5-3.

Table 6.5-3
Forced Regression of ACEALL and CMQALL with ATM Measures*
(n=40)

Equation	Multiple R	% Variance
1.) ATMALL = (-.004) CMQALL + .42 ACEALL + 1.03	.71	50
2.) ATM_13 = .06 CMQALL + .48 ACEALL + .60	.73	53
3.) ATM_12 = .03 CMQALL + .43 ACEALL + .95	.66	44
4.) BIGRADE = .03 CMQALL + .73 ACEALL + (-.36)	.69	48
5.) TASK1071 = .34 CMQALL + .95 ACEALL + (-2.83)	.74	55

* In all equations, F is significant at the $p < .001$ level.

Table 6.5-3 shows that the combination of the CMQALL and ACEALL scales account for approximately the same percent of variance as the does the ACEALL measure alone (see Table 6.2-3), thus indicating that the CMQALL adds little to the equations. This observation was

confirmed when the stepwise regressions were calculated. In those equations, CMQALL consistently dropped from the equation, thereby producing the same results as found in Table 6.2-3.

6.6 Predict Mission Performance Variables Using ACE Scales

The ACE Checklist subscales were forced into regression equations with the 9 simulator performance variables. The nine regression equations are at Table 6.6-1.

Table 6.6-1
Forced Regression of ACE Checklist Scales with Performance Measures+
(n=20)

Equation	Multiple R	% Variance
1.) NAVTIME = (-4.27) WORKMNG + 1.97 XNMITOR + .74 INFOEXC + (-1.72) TEAMACE + 41.55	.67	46 **
2.) DEVIATE# = (-.54) WORKMNG + .40 XMNITOR + (-.50) INFOEXC + (-.06) TEAMACE + 3.76	.60	36
3.) %OFFCOUR = (-14.50) WORKMNG + 7.09 XMNITOR + (-12.15) INFOEXC + 5.48 TEAMACE + 69.87	.62	39
4.) WITHIN = .14 WORKEXC + (-.22) XMNITOR + .20 INFOEXC + .22 TEAMACE + (-.89)	.59	35
5.) THRT# = (-2.02) WORKMNG + 1.6 XMNITOR + .27 INFOEXC + .02 TEAMACE + 4.62	.51	26
6.) THRTIME = (-32.40) WORKMNG + 20.39 XMNITOR + (-.92) INFOEXC + 3.39 TEAMACE + 83.81	.51	26
7.) THRTMAX = (-3.91) WORKMNG + .98 XMNITOR + (-5.04) INFOEXC + 1.65 TEAMACE + 40.06	.39	16
8.) MEANDUR = (-.82) WORKMNG + (-.48) XMNITOR + 1.21 INFOEXC + (-.74) TEAMACE + 15.09	.22	5
9.) ILSRIGHT = (-6.98) WORKMNG + (-10.71) TEAMACE + 14.94 XMNITOR + 2.18 INFOEXC + 90.10	.61	38

+ Levels of significance are: *** $p < .01$ ** $p < .05$, and * $p < .10$.

Table 6.6-1 demonstrates that the ACE scales have a moderate ability to predict mission performance. Although the multiple R values are high, it was difficult to obtain statistical significance because the degrees of freedom were relatively high compared to the sample size, i.e., with Crew #4 "missing", df = 4, 14. To gain further clarity with respect to these equations, the ACE Checklist subscales were entered into the equations in a stepwise manner to determine which subscales offered the most predictive power. Table 6.6-2 shows these results.

Table 6.6-2
Stepwise Regression of ACE Checklist Scales with Performance Variables*
(n=20)

Equation	Multiple R	% Variance
1.) NAVTIME = (-3.53) WORKMNG + 41.80	.61	37
2.) DEVIATE# = (-.58) WORKMNG + 3.41	.53	28
3.) %OFFCOUR = (-12.68) WORKMNG + 68.40	.54	29
4.) WITHIN = .28 TEAMACE + (-.72)	.49	24
5.) THRT# = NE[1]		
6.) THRTIME = NE		
7.) THRTMAX = NE		
8.) MEANDUR = NE		
9.) ILSRIGHT = NE		

* In all equations developed, F is significant at the $p < .03$ level.

Table 6.6-2 shows that two ACE subscales are good predictors for certain performance measures. Interestingly, in the Table 6.6-2 equations, lower multiple R values result in statistical significance. As noted in the discussion of Table 6.6-1, the degrees of freedom are lower; i.e, df = 1, 17, in the stepwise equations when only one variable enters the equation. Singularly, the WORKMNG subscale predicts performance for the NAVTIME, DEVIATE#, and %OFFCOUR measures. Note that since three of the significant equations predict navigation performance, evidence is provided that effective Workload Management influences navigation success. It is also noted that TEAMACE best predicts WITHIN in the same manner.

6.7 Predict Mission Performance Variables Using CMAQ "Logical" Scales

The CMAQ subscales were forced into the regression equations with the performance measures. Table 6.7-1 shows the resultant equations.

[1] NE = No equation derived.

Table 6.7-1
Forced Regression of CMAQ "Logical" Scales with Performance Measures*
(n=40)

Equation	Multiple R	% Variance
1.) NAVTIME = (-2.26) HLPCMAQ + 1.13 TEAMCMAQ + .37 CREWFAL + (-1.59) GIVEGET + 44.85	.34	12
2.) DEVIATE# = .15 HLPCMAQ + (-.18) TEAMCMAQ + (-.14) CREWFAL + .10 GIVEGET + 1.73	.14	2
3.) %OFFCOUR = .69 HLPCMAQ + (-4.42) TEAMCMAQ + 2.06 CREWFAL + (-4.68) GIVEGET + 62.95	.17	3
4.) WITHIN = (-.25) HLPCMAQ + (-.29) TEAMCMAQ + .06 CREWFAL + .38 GIVEGET + .77	.36	13
5.) THRT# = (-.11) HLPCMAQ + .20 TEAMCMAQ + (-1.10) CREWFAL + (-.35) GIVEGET + 11.44	.27	7
6.) THRTIME = (-4.73) HLPCMAQ + (-2.77) TEAMCMAQ + (9.16) CREWFAL + .25 GIVEGET + 141.81	.19	4
7.) THRTMAX = (-2.32) HLPCMAQ + (-2.66) TEAMCMAQ + 4.43 CREWFAL + 2.81 GIVEGET + 9.21	.20	4
8.) MEANDUR = (-1.40) HLPCMAQ + (-2.36) TEAMCMAQ + 2.13 CREWFAL + 1.29 GIVEGET + 14.22	.24	6
9.) ILSRIGHT = 4.25 HLPCMAQ + 4.66 CREWFAL + 4.41 TEAMCMAQ + (-10.97) GIVEGET + 74.64	.34	12

* In all equations, F is <u>not</u> significant at the $p < .05$ level.

Table 6.7-1 further corroborates the finding that the CMAQ, by itself, has little predictive value predicting performance in this context. Since the percent of variance explained is not significant, stepwise regressions were not computed.

6.8 Predict Performance Variables Using CMAQ "Logical" Scales, ACE Scales, and ATMALL

The ACE subscales, CMAQ subscales, and the ATMALL measure (29 ATM Task scale) were forced into the regression equations with the nine simulator performance variables. ATMALL was used in lieu of the various ATM subscales because use of the ATM subscales would have introduced interdependency among the predictor variables rendering the results uninterpretable. Table 6.8-1 shows the resulting regression equations.

Table 6.8-1
Forced Regression of CMAQ "Logical" Scales,
ACE Checklist Scales, and ATMALL
with Performance Measures+
(n=40)

Equation	Multiple R	% Variance
1.) NAVTIME = (-2.87) ATMALL + .87 TEAMCMAQ + (-2.63) HLPCMAQ + (-.68) INFOEXC + 1.90 CREWFAL + (-1.28) GIVEGET + (-3.62) WORKMNG + 2.82 XMNITOR + (-1.24) TEAMACE + 54.72	.77	60 ***
2.) DEVIATE# = (-1.30) ATMALL + (-.24) TEAMCMAQ + (-.03) HLPCMAQ + (-.66) INFOEXC + .20 CREWFAL + .16 GIVEGET + (-.46) WORKMNG + .69 XMNITOR + .23 TEAMACE + 4.65	.72	52 ***
3.) %OFFCOUR = (-8.58) ATMALL + (-6.57) TEAMCMAQ + (-5.06) HLPCMAQ + (-15.59) INFOEXC + 9.36 CREWFAL + (-1.08) GIVEGET + (-13.92) WORKMNG + 9.96 XMNITOR + 7.54 TEAMCMAQ + 105.16	.68	46 **
4.) WITHIN = (-.35) ATMALL + (-.27) TEAMCMAQ + (-.14) HLPCMAQ + .13 INFOEXC + (-.03) CREWFAL + .30 GIVEGET + .19 WORKMNG + (-.15) XMNITOR + .31 TEAMACE + .06	.71	50 ***
5.) THRT# = (-3.17) ATMALL + .05 TEAMCMAQ + .42 HLPCMAQ + .05 INFOEXC + (-.43) CREWFAL + (-.49) GIVEGET + (-1.54) WORKMNG + 2.11 XMNITOR + .54 TEAMACE + 9.97	.60	36
6.) THRTIME = (-44.44) ATMALL + (-5.65) TEAMCMAQ + (-1.09) HLPCMAQ + (-6.47) INFOEXC + 2.91 CREWFAL + .37 GIVEGET + (-27.32) WORKMNG + 29.16 XMNITOR + 12.01 TEAMACE + 149.65	.59	35
7.) THRTMAX = (-15.02) ATMALL + (-3.23) TEAMCMAQ + (-4.87) HLPCMAQ + (-8.65) INFOEXC + 7.74 CREWFAL + 3.46 GIVEGET + (-3.65) WORKMNG + 5.32 XMNITOR + 5.44 TEAMACE + 44.38	.59	35
8.) MEANDUR = (-2.99) ATMALL + (-2.32) TEAMCMAQ + (-1.22) HLPCMAQ + .35 INFOEXC + 2.48 CREWFAL + 1.10 GIVEGET + (-.87) WORKMNG + .47 XMNITOR + .10 TEAMACE + 19.18	.38	14
9.) ILSRIGHT = (-.63) ATMALL + 6.78 CREWFAL + 5.17 HLPCMAQ + (-6.38) WORKMNG + 2.18 TEAMCMAQ + (-10.44) GIVEGET + 15.32 XMNITOR + (-9.17) TEAMACE + 1.06 INFOEXC + 70.18	.71	51 ***

+ Levels of significance are: *** $p < .01$ ** $p < .05$, and * $p < .10$.

The equations developed in Table 6.8-1 demonstrate that, when considered together, the CMAQ scales, ACE Checklist scales and ATMALL have considerable predictive power in determining performance - especially navigation-related performance. By entering the independent variables in a stepwise manner, it was expected that the better predictors would become apparent. Table 6.8-2 shows these results.

Table 6.8-2
Stepwise Regression of CMAQ "Logical" Scales, ACE Checklist Scales, and ATMALL with Performance Variables*
(n=40)

Equation	Multiple R	% Variance
1.) NAVTIME = (-3.48) WORKMNG + (-2.62) HLPCMAQ + 56.97	.68	46
2.) DEVIATE# = (-.58) WORKMNG + 3.41	.53	28
3.) %OFFCOUR = (-12.68) WORKMNG + 68.40	.54	29
4.) WITHIN = .44 TEAMACE + (-.42) ATMALL + (-.31)	.56	32
5.) THRT# = NE		
6.) THRTIME = (-31.25) WORKMNG + 21.20 XMNITOR + 86.54	.51	26
7.) THRTMAX = (-12.19) ATMALL + 49.39	.41	17
8.) MEANDUR = NE		
9.) ILSRIGHT = 13.36 XMNITOR + (-11.75) TEAMACE + 82.52	.58	34

* In all equations, F is significant at the $p < .01$ level.

In these equations, it can be seen that one of the CMAQ subscales (HLPCMAQ), three of the ACE subscales (WORKMNG, XMNITOR, and TEAMACE), and the ATMALL measure significantly contribute to at least one simulator mission performance variable. Inspection of the computer printouts of the stepwise entry of the variables revealed that in most equations the ACE accounted for the predominant amount of the variance. Of particular note is the fact that an attitude subscale (HLPCMAQ) entered the stepwise regression indicating its statistical significance. This finding was very important and encouraged further analyses to better understand the relationship between attitude and performance.

6.9 Predict Performance Variables Using ATMALL, CMQALL, and ACEALL

The ATMALL, CMQALL, and ACEALL measures were forced into regression equations with the nine simulator performance variables. The results of these analyses can be seen in Table 6.9-1.

Table 6.9-1
Forced Regression of ATMALL, ACEALL, and CMQALL with Performance Measures+
(n=40)

Equation	Multiple R	% Variance
1.) NAVTIME = (-2.52) CMQALL + (-2.37) ATMALL + (-2.11) ACEALL + 56.56	.52	27 ***
2.) DEVIATE# = (-.08) CMQALL + (-.76) ATMALL + (-.31) ACEALL + 4.81	.54	30 ***
3.) %OFFCOUR = (-6.61) CMQALL + 1.46 ATMALL + (-13.73) ACEALL + 104.87	.49	24 **
4.) WITHIN = (-.01) CMQALL + (-.44) ATMALL + .48 ACEALL + (-.24)	.57	32 ***
5.) THRT# = (-1.51) CMQALL + (-2.17) ATMALL + .93 ACEALL + 14.46	.33	11
6.) THRTIME = (-16.88) CMQALL + (-29.48) ATMALL + 4.70 ACEALL + 200.45	.31	10
7.) THRTMAX = 3.25 CMQALL + (-9.64) ATMALL + (-2.05) ACEALL + 32.44	.44	19 *
8.) MEANDUR = .32 CMQALL + (-3.31) ATMALL + .43 ACEALL + 16.68	.26	9
9.) ILSRIGHT = 2.26 CMQALL + 2.70 ACEALL + 6.81 ATMALL + 45.19	.28	8

+ Levels of significance are: *** p < .01 ** p < .05, and * p < .10.

Table 6.9-1 shows that the ATMALL, CMQALL, and ACEALL measures, taken together, are able to explain a significant amount of the variance of several performance measures, especially those variables that are navigation-related.

Stepwise regressions were next computed, and the results are shown in Table 6.9-2.

Table 6.9-2
Stepwise Regression of ACEALL, ATMALL, and CMQALL with Performance Measures*
(n=40)

Equation	Multiple R	% Variance
1.) NAVTIME = (-3.06) ACEALL + 40.42	.45	20
2.) DEVIATE# = (-1.15) ATMALL + 4.24	.52	27
3.) %OFFCOUR = (-13.04) ACEALL + 70.68	.47	22
4.) WITHIN = .48 ACEALL + (-.44) ATMALL + (-.28)	.57	32
5.) THRT# = NE		
6.) THRTIME = NE		
7.) THRTMAX = (-12.19) ATMALL + 49.39	.41	17
8.) MEANDUR = NE		
9.) ILSRIGHT = NE		

* In all equations, F is significant at the p < .01 level.

Table 6.9-2 indicates that, as in Paragraph 6.5, the CMQALL scale again drops from all equations when stepwise entry is used. Inspection of the results shows the ATMALL scale to be the best predictor of DEVIATE# and THRTMAX while The ACEALL scale is the best predictor of NAVTIME, %OFFCOUR, and WITHIN.

6.10 Summary

Several of the equations presented in this Section demonstrate that the ACE Checklist scales are powerful predictors of ATM Task performance. Likewise, ACE scales are also good predictors of the simulator performance measures.

ATMALL proved to be a powerful predictor of performance. This finding was encouraging since ATM Task performance is a central component of the APART program and lends credibility to the APART reliance on the ATM Tasks.

The performance of the CMAQ "logical" scales when using a sample size of 40 was mildly encouraging. Analysis indicated some relationship between attitudes (the Army CMAQ) and behavior (as rated on the ACE and the Gradeslips) and mission performance in the simulator. In short, the attitude → behavior/performance linkage was established, albeit a weak one.

Section 7 will focus on the question of how well the CMAQ "factor" scales perform in depicting the attitude → behavior/performance relationship.

Section 7.0
Relationships Among the Measures: CMAQ "Factor" Scales

7.1 Introduction

The results presented in the previous Section demonstrate the strong statistical relationships among the ACE Checklist, ATM Tasks, and simulator performance variables. The measures were shown to have performed as expected. Since the relationship between attitudes (the Army CMAQ "logical" scales) and the other meaures was less than postulated, alternative ways of analyzing the data were sought. The next Sections present various explorations of the CMAQ data, and present several interesting conclusions.

Gregorich et al. (1990) used a factor analytic model to develop the CMAQ scales used in the NASA/UT analyses. As discussed in Paragraph 2.5, the Army CMAQ revealed three factors very similar to those of the NASA/UT analysis. Thus, it was decided to use the three factors derived from the Army CMAQ factor analysis and recompute certain of the equations found in Section 6. This Section presents the results.

The variable names used in this Section, including the Army CMAQ "factor" scale names, were listed previously in Table 6.1-1. The organizational chart for this Section is at Table 7.1-1.

Table 7.1-1
Organizational Chart for Section 7

Analysis/Equation	Interpretation	Table(s)
7.2 Predict ATM performance using CMAQ "factor" scales	CMAQ "factor" scales are not predictive of ATM performance.	7.2-1
7.3 Predict ACE performance using CMAQ "factor" scales	CMAQ "factor" scales are not predictive of ACE performance.	7.3-1
7.4 Predict ATM performance using CMAQ "factor" scales and ACE scales	More variance explained than either independent variable alone. CMAQ "factor" scales drop from the stepwise equations.	7.4-1
7.5 Predict ATM performance using ACEALL and CMAQ34	High predictive value when taken together; CMAQ34 drops from the equation when scales are entered stepwise.	7.5-1
7.6 Predict performance variables using CMAQ "factor" scales	CMAQ "factor" scales have some predictive value.	7.6-1, 7.6-2
7.7 Predict performance variables using CMAQ "factor" scales, ACE scales, and ATMALL	Mission performance can be predicted. At least one scale from each of the three instruments enters the stepwise equations.	7.7-1, 7.7-2
7.8 Predict performance variables using ATMALL, CMAQ34, and ACEALL	The three measures have moderate predictive power; CMAQ34 slightly improves prediction, but drops from the stepwise equation.	7.8-1

7.2 Predict ATM Performance Using CMAQ "Factor" Scales

The three factor scales[2] (COMMCOR, SHARLEAD, STRESS) were forced into equations with the five ATM scales. Table 7.2-1 shows the resultant data.

Table 7.2-1
Forced Regressions of CMAQ "Factor" Scales with ATM Measures*
(n=40)

Equation	Multiple R	% Variance
1.) ATMALL = (-.07) STRESS + .11 COMMCOR + (-.01) SHARLEAD + 2.05	.16	3
2.) ATM_13 = (-.01) STRESS + (-.02) COMMCOR + .04 SHARLEAD + 2.41	.05	0
3.) ATM_12 = (-.02) STRESS + (-.03) COMMCOR + .03 SHARLEAD + 2.58	.05	0
4.) BIGRADE = (-.02) STRESS + .21 COMMCOR + (-.10) SHARLEAD + 1.58	.11	1
5.) TASK1071 = .10 STRESS + .10 COMMCOR + .06 SHARLEAD + .83	.15	2

* In all equations, F is not significant at the p < .05 level.

This table can be compared to Table 6.3-1, which reports the results of similar analyses performed with the CMAQ "logical" scales. Although the "factor" scales have higher reliabilities than the "logical" scales, the CMAQ still has insignificant predictive value in determining ATM performance. Comparison by inspection of Tables 6.3-1 and 7.2-1 indicates that the "logical" scales are slightly better in accounting for variance in ATM Task performance. Since F was not significant, stepwise regression equations were not computed.

7.3 Predict ACE Performance Using CMAQ "Factor" Scales

Next, the three CMAQ "factor" scales were forced into equations with the six ACE subscales. The results, shown in Table 7.3-1, are similar to those presented in Table 6.4-1. The CMAQ, in either its "logical" or "factor" form, has little predictive value when regressed with the ACE measures. A possible explanation for this finding is presented in Paragraph 7.9.

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[2] Note: CMAQ34 was not included in the regression equations because its use would introduce interdependency among the predictor variables. It will be entered singly, or in conjunction with other overall scales, in later analyses.

Table 7.3-1
Forced Regression of CMAQ "Factor" Scales with ACE Measures*
(n=40)

Equation	Multiple R	% Variance
1.) ACEALL = (.01) STRESS + .26 COMMCOR + (-.13) SHARLEAD + 2.49	.14	2
2.) TEAMACE = (-.08) STRESS + .02 COMMCOR + .03 SHARLEAD + 3.66	.09	1
3.) XMNITOR = (-.02) STRESS + .21 COMMCOR + (-.18) SHARLEAD + 3.15	.12	2
4.) INFOEXC = .04 STRESS + .33 COMMCOR + (-.29) SHARLEAD + 2.66	.24	6
5.) WORKMNG = (-.002) STRESS + .43 COMMCOR + (-.01) SHARLEAD + .75	.22	5
6.) GLOBAL = (-.06) STRESS + .38 COMMCOR + (-.10) SHARLEAD + 1.87	.15	2

* In all equations, F is not significant at the $p < .05$ level.

7.4 Predict ATM Performance Using CMAQ "Factor" Scales and ACE Scales

The three CMAQ "factor" scales and four ACE subscales were then forced into equations with the ATM Task subscales as the dependent variable. Table 7.4-1 shows the results of the forced regression.

Table 7.4-1
Forced Regression of CMAQ "Factor" Scales and ACE Scales with ATM Measures*
(n=40)

Equation	Multiple R	% Variance
1.) ATMALL = .10 WORKMNG + (-.04) STRESS + (-.01) SHARLEAD + (.06) COMMCOR + .18 XMNITOR + (-.12) INFOEXC + .23 TEAMACE + .91	.78	61
2.) ATM_13 = .23 WORKMNG + .02 STRESS + .02 SHARLEAD + (-.10) COMMCOR + .21 XMNITOR + (-.19) INFOEXC + .19 TEAMACE + 1.37	.82	67
3.) ATM_12 = .28 WORKMNG + .01 STRESS + (-.01) SHARLEAD + (-.11) COMMCOR + .21 XMNITOR + (-.26) INFOEXC + .17 TEAMACE + 1.81	.79	63
4.) BIGRADE = .51 WORKMNG + (-.004) STRESS + (-.09) SHARLEAD + (-.02) COMMCOR + .31 XMNITOR + (-.17) INFOEXC + .003 TEAMACE + .66	.76	59
5.) TASK1071 = (-.24) WORKMNG + .12 STRESS + .24 SHARLEAD + (-.03) COMMCOR + .24 XMNITOR + .53 INFOEXC + .44 TEAMACE + (-2.77)	.79	63

* In all equations, F is significant at the $p < .0001$ level.

The results, in terms of the percent of variance explained in Table 7.4-1, are nearly identical to those presented in Table 6.5-1. When the data are allowed to enter the equation in a stepwise manner, the results are the same as those shown in Table 6.5-2; i.e., the CMAQ scales drop from the equation.

7.5 Predict ATM Performance Using ACEALL and CMAQ34

The CMAQ34 and ACEALL scales were forced into equations with the ATM Task subscales. These equations are at Table 7.5-1 and are nearly identical to those at Table 6.5-3. When allowed to enter stepwise, only ACEALL enters and the equations are the same as those in Table 6.2-3.

Table 7.5-1
Forced Regression of CMAQ34 and ACEALL Scales
with ATM Measures*
(n=40)

Equation	Multiple R	% Variance
1.) ATMALL = (-.02) CMAQ34 + .42 ACEALL + 1.13	.71	50
2.) ATM_13 = .01 CMAQ34 + .47 ACEALL + .85	.72	53
3.) ATM_12 = (-.02) CMAQ34 + .43 ACEALL + 1.18	.66	44
4.) BIGRADE = (-.01) CMAQ34 + .73 ACEALL + (-.16)	.69	48
5.) TASK1071 = .25 CMAQ34 + .94 ACEALL + (-2.32)	.74	55

* In all equations, F is significant at the p < .0001 level.

7.6 Predict Performance Variables Using CMAQ "Factor" Scales

The CMAQ "factor" scales were placed into regression equations with the mission performance variables as the dependent measure. Tables 7.6-1 and 7.6-2, respectively, show the results of both the forced and stepwise entry of the CMAQ "factor" scales into the regression equations.

Table 7.6-1
Forced Regression of CMAQ "Factor" Scales
with Performance Measures+
(n=40)

Equation	Multiple R	% Variance
1.) NAVTIME = 1.12 STRESS + (-3.17) COMMCOR + (-1.51) SHARLEAD + 52.97	.41	17 *
2.) DEVIATE# = .19 STRESS + (-.66) COMMCOR + .21 SHARLEAD + 3.42	.30	9
3.) %OFFCOUR = 2.41 STRESS + (-24.96) COMMCOR + 6.36 SHARLEAD + 128.61	.45	20 **
4.) WITHIN = .02 STRESS + (-.02) COMMCOR + .004 SHARLEAD + .26	.04	0
5.) THRT# = (-.39) STRESS + .35 COMMCOR + (-.88) SHARLEAD + 8.87	.27	7
6.) THRTIME = (-3.87) STRESS + (-2.02) COMMCOR + (-8.76) SHARLEAD + 133.51	.22	5
7.) THRTMAX = .83 STRESS + (-4.59) COMMCOR + 2.54 SHARLEAD + 29.66	.16	2
8.) MEANDUR = .29 STRESS + (-1.61) COMMCOR + .21 SHARLEAD + 19.12	.14	2
9.) ILSRIGHT = 1.00 STRESS + (-.47) COMMCOR + (-1.28) SHARLEAD + 89.08	.07	1

+ Levels of significance are: *** p < .01, **p < .05, and * p < .10.

Table 7.6-2
Stepwise Regression of CMAQ "Factor" Scales with Performance Measures*
(n=40)

Equation	Multiple R	% Variance
1.) NAVTIME = (-3.74) COMMCOR + 52.59	.33	11
2.) DEVIATE# = NE		
3.) %OFFCOUR = (-17.70) COMMCOR + 132.40	.39	15
4.) WITHIN = NE		
5.) THRT# = NE		
6.) THRTIME = NE		
7.) THRTMAX = NE		
8.) MEANDUR = NE		
9.) ILSRIGHT = NE		

* In all equations, F is significant at the $p < .05$ level.

A note of explanation is offered at this point. Previously, in Table 6.7-1, equations were built using the CMAQ "logical" scales; however, since none of the equations were significant, stepwise regressions could not be computed. As shown in Tables 7.6-1 and 7.6-2, the CMAQ "factor" scales do have predictive value when regressed with the performance variables. In fact, Table 7.6-1 shows that significant results were obtained when the CMAQ "factor" scales were used in the equations. This finding made it possible to develop the equations presented in Table 7.6-2. Again, Tables 7.6-1 and 7.6-2 give evidence to the linkage between attitudes and performance as noted earlier in Paragraph 6.10.

7.7 Predict Performance Variables Using the CMAQ "Factor" Scales, ACE Scales, and ATMALL

To determine the net effect of the measurement suite on performance, the three CMAQ "factor" scales, the four ACE subscales, and the ATMALL measure were forced into regression equations with the nine performance variables. The results are at Table 7.7-1.

Table 7.7-1
Forced Regression Using CMAQ "Factor" Scales, ACE Checklist Scales, and ATMALL with Performance Variables+
(n=40)

Equation	Multiple R	% Variance
1.) NAVTIME = (-2.11) ATMALL + (-.89) SHARLEAD + .94 STRESS + (-2.20) COMMCOR + .09 INFOEXC + (-3.42) WORKMNG + 2.31 XMNITOR + (-1.40) TEAMACE + 57.66	.74	54 ***
2.) DEVIATE# = (-1.22) ATMALL + .14 SHARLEAD + .17 STRESS + (-.31) COMMCOR + (-.60) INFOEXC + (-.42) WORKMNG + .66 XMNITOR + .15 TEAMACE + 5.25	.74	54 ***
3.) %OFFCOUR = (-5.66) ATMALL + 4.04 SHRALEAD + 2.96 STRESS + (-17.28) COMMCOR + (-11.07) INFOEXC + (-11.30) WORKMNG + 8.32 XMNITOR + 3.14 TEAMACE + 140.50	.70	49 ***
4.) WITHIN = (-.41) ATMALL + .02 SHARLEAD + .001 STRESS + (-.09) COMMCOR + .16 INFOEXC + .20 WORKMNG + (-.14) XMNITOR + .28 TEAMACE + (-.08)	.65	42 **
5.) THRT# = (-3.37) ATMALL + (-.50) SHARLEAD + (-.48) STRESS + .85 COMMCOR + (-.25) INFOEXC + (-1.57) WORKMNG + 2.19 XMNITOR + .74 TEAMACE + 8.15	.62	39 **
6.) THRTIME = (-46.48) ATMALL + (-5.58) SHARLEAD + (-4.77) STRESS + 9.16 COMMCOR + (-7.78) INFOEXC + (-26.52) WORKMNG + 28.67 XMNITOR + 13.34 TEAMACE + 131.96	.61	37 *
7.) THRTMAX = (-14.34) ATMALL + .99 SHARLEAD + .68 STRESS + (-.66) COMMCOR + (-6.34) INFOEXC + (-2.62) WORKMNG + 3.88 XMNITOR + 4.38 TEAMACE + 49.90	.51	26
8.) MEANDUR = (-2.81) ATMALL + .72 SHARLEAD + .02 STRESS + (-1.79) COMMCOR + 1.23 INFOEXC + (-.26) WORKMNG + .08 XMNITOR + (-.69) TEAMACE + 24.22	.31	9
9.) ILSRIGHT = 3.15 ATMALL + (-1.38) COMMCOR + 1.04 STRESS + 2.34 INFOEXC + (-.33) SHARLEAD + (-6.92) WORKMNG + 14.44 XMNITOR + (-11.58) TEAMACE + 92.44	.62	38 *

+ Levels of significance are: *** p < .01, ** p < .05, and * p < .10.

Table 7.7-1 can be compared to Table 6.8-1. On inspection, both tables have similar percentages of variance explained, but the use of the CMAQ "factor" scales results in a greater number of statistically significant equations being developed. This finding lends additional support to the notion that the "factor" scales are better than the "logical" scales in prediction of performance.

Next, by allowing the independent variables to enter the equation in a stepwise manner, it was expected that the more predictive variables would be revealed. Table 7.7-2 shows the results of these calculations.

Table 7.7-2
Stepwise Regression of CMAQ "Factor" Scales, ACE Checklist Scales, and ATMALL with Performance Measures*
(n=40)

Equation	Multiple R	% Variance
1.) NAVTIME = (-3.53) WORKMNG + 41.80	.61	37
2.) DEVIATE# = (-.58) WORKMNG + 3.41	.53	28
3.) %OFFCOUR = (-11.24) WORKMNG + (-12.93) COMMCOR + 140.69	.61	37
4.) WITHIN = .44 TEAMACE + (-.42) ATMALL + (-.31)	.56	32
5.) THRT# = NE		
6.) THRTIME = (-31.25) WORKMNG + 21.20 XMNITOR + 86.54	.51	26
7.) THRTMAX = (-12.19) ATMALL + 49.39	.41	17
8.) MEANDUR = NE		
9.) ILSRIGHT = 13.36 XMNITOR + (-11.75) TEAMACE + 82.52	.58	33

* In all equations, F is significant at the $p < .01$ level.

Table 7.7-2 demonstrates that the CMAQ "factor" scales have some predictive power. Specifically, the COMMCOR factor becomes an important component in the prediction equation of the %OFFCOUR. This result is similar to that reported in Table 6.8-2, where a CMAQ "logical" scale (HLPCMAQ) appeared in a stepwise equation predicting another navigation-related variable (NAVTIME). Table 2.5-3 suggests a linkage between the "logical" scale entitled "Provide/Accept Help" (HLPCMAQ) and the "factor" scale entitled "Communication & Coordination" (COMMCOR). Interestingly, it is the HLPCMAQ scale in Table 6.8-2 and the COMMCOR scale in Table 7.7-2 that enter the stepwise equations as significant predictors of performance. Thus, there is corroborating evidence that 1) attitudes impact navigation-related performance, and 2) the HLPCMAQ and COMMCOR scales are related.

7.8 Predict Performance Variables Using ATMALL, CMAQ34, and ACEALL

In this analysis, the CMAQ34, ACEALL, and ATMALL were forced into regression equations as the independent variables with the performance measures as the dependent variable. Table 7.8-1 shows the results of these equations.

Table 7.8-1
Forced Regression of CMAQ34, ACEALL, and ATMALL with Performance Measures+
(n=40)

Equation	Multiple R	% Variance
1.) NAVTIME = (-2.66) CMAQ34 + (-2.52) ATMALL + (-1.98) ACEALL + 57.71	.54	29 ***
2.) DEVIATE# = .01 CMAQ34 + (-.77) ATMALL + (-.31) ACEALL + 4.31	.54	30 ***
3.) %OFFCOUR = (-7.65) CMAQ34 + 1.03 ATMALL + (-13.37) ACEALL + 111.64	.51	26 ***
4.) WITHIN = (.001) CMAQ34 + (-.44) ATMALL + .48 ACEALL + (-.27)	.57	32 ***
5.) THRT# = (-1.35) CMAQ34 + (-2.25) ATMALL + 1.00 ACEALL + 13.79	.34	11
6.) THRTIME = (-17.51) CMAQ34 + (-30.49) ATMALL + 5.54 ACEALL + 206.37	.33	11
7.) THRTMAX = .67 CMAQ34 + (-9.55) ATMALL + (-2.13) ACEALL + 46.44	.42	18 *
8.) MEANDUR = (-.62) CMAQ34 + (-.3.33) ATMALL + .44 ACEALL + 21.93	.27	7
9.) ILSRIGHT = .58 CMAQ34 + 2.60 ACEALL + 6.68 ATMALL + 54.89	.28	8

+ Levels of significance are: *** $p < .01$, ** $p < .05$, and * $p < .10$.

A comparison of Table 7.8-1 with Table 6.9-1 shows that using CMAQ34 versus CMAQALL produces marginally better prediction equations for navigation-related performance variables.

To determine if the use of CMAQ34 affected the stepwise regression equations, CMAQ34, ACEALL, and ATMALL were entered in stepwise fashion to predict the performance variables. However, CMAQ34 consistently dropped from the equations; therefore, the results of these computations are identical to those found in Table 6.9-2.

7.9 Summary

Sections 6 and 7 have shown that the ACE Checklist and ATM Task measures exhibit a strong relationship to each other and to mission performance. The CMAQ, in either its "logical" or "factor" form, helps to explain a small amount of additional variance in the prediction of ACE Checklist or ATM Task measures. However, it was very interesting to note that, in some cases, the CMAQ "factor" scales significantly added to the ability to predict mission performance variables. Close inspection of the results indicates that the CMAQ "factor" scales are slightly better predictors than the "logical" scales.

Establishment of the "better predictive" relationship of CMAQ "factor" scales to mission performance may be due in part to the comparatively better reliability of the two measures; i.e., the CMAQ "factor" scales are more reliable than the CMAQ "logical" scales; and the mission

performance measures are more reliable than the ACE Checklist or ATM Tasks. Consequently, there is less "noise" (or, unreliability) in the correlations between the CMAQ "factor" scales and the mission performance variables. Thus, with less "noise" present as an artifact of the measures, the true relationship can be established. This is not to say that the ACE and ATM measures are unreliable; rather, it indicates that the mission performance measures as collected in the simulator are relatively "objective" while the ACE Checklist and ATM Task measures, by definition, are subjective ratings; therefore, they are exposed to more "noise" in the data than the performance variables.

As a result of the analyses explained in Sections 6 and 7, a relationship was empirically established between attitudes towards crew coordination and performance. Based on DRC's literature review accomplished to date, this is the first time such a relationship has been shown empirically. While others have postulated or assumed the existence of such a relationship, none have empirically proved it. The fact that a relationship between attitudes and performance was established necessitated further analyses to better understand the nature of the relationship. Sections 8 and 9 present the analyses and results of this in-depth examination.

Section 8.0
Relationships Among the Measures Using the CMAQ "Logical" Scales: Various Crew Combinations

8.1 Introduction

In Sections 6 and 7, the results of regression equations with CMAQ, ATM, ACE, and performance measures were presented. Several findings affirmed that the CMAQ scales had slightly better predictive ability when the dependent variables were performance measures; and little, if any, predictive value when regressed against ATM or ACE scales. As stated in the Section 7 summary, the performance variables being objective measures are subject to less "noise" than the ATM or ACE measures, and this could account for the better regression equations in those cases.

It was determined that using the 40 CMAQ attitude observations to predict behavior/performance, when only 20 behavior/performance observations existed, was probably not the best approach. Multiple regression is a linear manipulation; but, by attempting to relate CMAQ attitudes, which are based on the individual (n=40), with ATM, ACE and/or performance variables, which are based on the crew (n=20), a bias in the view of the attitude → behavior/performance relationship is introduced. An example of the consequences is that when the CMAQ scales are regressed with the ATM scales, 40 ATM cases are considered against 40 CMAQ cases. The reality is that only 20 ATM observations are available. In the equations of Sections 6 and 7, this complication (40 observations onto 20 observations) is present for any instance when the CMAQ scales are used.

Accordingly, for both statistical and rational reasons, it was postulated that a <u>combination</u> of attitudes within an aircrew exists and that some combination of Pilot-in-Command (PC) and Pilot (PI) attitudes may better depict the relationship between attitudes and actions. Thus, Sections 8 and 9 will address the issue of whether a combination of PC-PI attitudes better predicts behavior/performance than the PC and PI considered independently. Also addressed is the combination of PC-PI attitudes that account for the most variance in predicting behavior/performance. Section 8 incorporates the CMAQ "logical" scales in the analyses; Section 9 uses the CMAQ "factor" scales in a similar set of analyses.

To accomplish the analyses, an alteration of the testbed database was required. Instead of a 40-case database, a 20-case database was developed. This 20-case database differentiated the CMAQ scores of the PC from the PI within one record; treating the aircrew as one "case." It was then possible to have a one-to-one observation ratio. The next step was to determine which elements of this database most influenced performance.

It was initially hypothesized that certain elements of the research data might have a greater influence than others on the relationships between attitudes and performance. For example, it could be that only the attitude of the PC was the key driver of good performance in a situation

where the PC had a "good" attitude, the PI had a "bad" attitude, and the crew received high ACE and ATM ratings. This line of inquiry gave rise to many similar questions. To answer them, 10 combinations of PC-PI CMAQ scores were created. The variable names and descriptions of the combinations are presented in Table 8.1-1.

Table 8.1-1
Aircrew (PC-PI) CMAQ Combination Scores

Variable Name	Description and Formula
PCONLY	The PC score only.
PIONLY	The PI score only.
PCANDPI	The total of the PC and PI score. (PC + PI)
DBL_PC	Two times the PC plus PI. ((2 * PC) + PI)
ABSDIF	The absolute value of the difference between the PC and PI. $\lvert PC - PI \rvert$
REALDIF	The difference of the PC minus PI. (PC - PI).
AD_BAD	Only the "bad" attitude in the cockpit, i.e., the lower score of either the PC or PI.
AD_GOOD	Only the "good" attitude in the cockpit, i.e., the higher score of either the PC or PI.
DBL_BAD	Two times the "bad" attitude plus the "good" attitude. $((2 * BAD_{PC\ or\ PI}) + (1 * GOOD_{PC\ or\ PI}))$
DBL_GOOD	Two times the "good" attitude plus the "bad" attitude. $((2 * GOOD_{PC\ or\ PI}) + (1 * BAD_{PC\ or\ PI}))$

The CMAQ "logical" scales comprise five attribute scales: TEAMCMAQ, CREWFAL, GIVEGET, HLPCMAQ, and CMQALL. These five scales were weighted by the ten different CMAQ combination scores described in Table 8.1-1 and correlated with the ATM, ACE, and performance measures. The complete bivariate correlation matrix is in Appendix E. Likewise, the CMAQ "factor" scales comprise four attribute scales: COMCORR, SHARLEAD, STRESS, and CMAQ34. The four "factor" scales were weighted by the ten different CMAQ combination scores and correlated with the ATM, ACE and performance measures; the correlation matrix for which is presented at Appendix F.

Clearly, it was not feasible to perform all subsequent analyses using all 10 aircrew attitude combination scores. Examination of the correlation matrices provided valuable insights as to how to efficiently approach the data analysis. Of the ten possible CMAQ weights, three in particular consistently resulted in higher correlations: PCONLY, PCANDPI, and ABSDIF. Thus, only these three combination scores were included in subsequent analyses.

A salient modification to be noted between Sections 6 & 7 and Sections 8 & 9 is that in the latter two Sections, the probabilities of F-to-enter and F-to-remove from any regression equation were relaxed to the $p < .15$ and $p < .16$, respectively. In other words, instead of the probability of F-to-enter being .05, as in the previous analyses (Sections 6 & 7), it was increased so that the F-to-enter probability had to be only .15 or less (Sections 8 & 9). The relaxed criteria permitted more opportunities to observe how the CMAQ scales functioned in stepwise regression

equations. Since a quantitative link had already been demonstrated in Sections 6 & 7, and because the sample size is small and the nature of this research is exploratory, this modification seemed reasonable.

Regression equations were computed using ATM, ACE, and performance measures as dependent variables, and CMAQ scales as independent variables in the form of the three different weights: PCONLY, PCANDPI, and ABSDIF. Since the objective of this research thrust was to determine the "best" CMAQ predictor combination, only the variable entered on the first step is presented in the following tables. Furthermore, if more than one predictor combination were entered into an equation, the resulting Beta weights would have been uninterpretable since the independent variables would have been dependent upon one another.

In this Section analyses using the Army CMAQ "logical" scales are presented; Section 9 uses the Army CMAQ "factor" scales. Table 8.1-2 is the organizational chart for the remainder of this Section.

Table 8.1-2
Organizational Chart for Section 8:
Army CMAQ "Logical" Scales

Analysis/Equation	Interpretation	Table(s)
8.2 Crew attitude combinations of TEAMCMAQ Scale to predict behavior/ performance	No predictive value in any of the three weights across all performance measures	None
8.3 Crew attitude combinations of CREWFAL Scale to predict behavior/performance	ABSDIF predicts TASK1071; PCONLY negatively predicts THRTMAX	None (in text)
8.4 Crew attitude combinations of HLPCMAQ Scale to predict behavior/performance	ABSDIF consistently predicts ATM Task measures; PCONLY or ABSDIF predict several ACE measures; PCANDPI and ABSDIF predict several performance variables.	8.4-1, 8.4-2, 8.4-3
8.5 Crew attitude combinations of GIVEGET Scale to predict behavior/performance	ABSDIF predicts three of the five ATM Task measures; ABSDIF predicts XMNITOR; PCONLY or ABSDIF predict several performance variables.	8.5-1, in text, and 8.5-2
8.6 Crew attitude combinations of CMQALL Scale to predict behavior/performance	ABSDIF predicts BIGRADE, XMNITOR and ILSRIGHT; PCONLY predicts THRT#.	In text and 8.6-1

8.2 Crew Attitude Combinations of TEAMCMAQ Scale to Predict Behavior/Performance

The three weights (PCONLY, PCANDPI, ABSDIF) of the TEAMCMAQ scale were regressed with the ATM measures, the ACE subscales, and the performance variables. Despite the relaxed criteria of F-to-enter and F-to-remove, none of the TEAMCMAQ weightings entered into any regression equation.

8.3 Crew Attitude Combinations of CREWFAL Scale to Predict Behavior/Performance

The CREWFAL scale proved a somewhat better indicator than the TEAMCMAQ scale. One equation to predict ATM performance was developed:

$$\text{TASK1071} = (-.90)\ \text{ABSDIF} + 2.61$$

The above equation has a multiple R of .44 and explains 19 percent of the variance (F is significant at the $p < .05$). As will be shown, this is the only equation, including both "logical" and "factor" scales, built around the TASK1071 measure. The equation can be interpreted to indicate that as the more similar a crew's attitude regarding crew fallibility is, the better their rating on Task 1071.

Using the three CREWFAL weights to predict ACE scores resulted in no equations being developed.

When regressed with the simulator performance variables, one equation developed:

$$\text{THRTMAX} = 7.39\ \text{PCONLY} + (-17.15)$$

The equation had a multiple R equal to .35, and explained 12% of the variance (F is significant at the $p < .14$ level). Since the THRTMAX variable measures the longest duration of any one threat encounter, lower THRTMAX values signify better performance. In the above regression equation, a positive Beta coefficient for the PCONLY weight indicates that a higher PC score on the CREWFAL measure predicts worse performance. Perhaps, if the PC's CREWFAL score is high, he believes his fellow crewmember to be error-prone, thus he fails to distribute workload, becomes task saturated, and performs poorly. As will be seen in other analyses, a positive attitude predicting worse performance is not usually the case.

8.4 Crew Attitude Combinations of HLPCMAQ Scale to Predict Behavior/Performance

The three weightings of the HLPCMAQ scales were regressed onto the ATM, ACE, and performance measures. The results of the ATM regressions can be seen in Table 8.4-1.

Table 8.4-1
Results of Stepwise Regression (First Step Only):
HLPCMAQ (3 Weights) as Independent Variables and
ATM Task Measures as Dependent Variables*
(n=20)

Equation	Multiple R	% Variance
1.) ATMALL = (-.53) ABSDIF + 2.66	.56	32
2.) ATM_13 = (-.61) ABSDIF + 2.79	.58	34
3.) ATM_12 = (-.61) ABSDIF + 2.82	.60	35
4.) BIGRADE = (-1.28) ABSDIF + 2.87	.76	58
5.) TASK1071 = NE		

* In all equations, F is significant at the $p < .01$ level.

The results of Table 8.4-1 indicate that the ABSDIF weight is the most predictive of the ATM measures. The negative coefficients were expected; the more similar (lower absolute difference) crewmembers score on the HLPCMAQ scale, the higher they score on rated ATM Tasks. A link therefore exists between similarity of crewmember attitudes on the HLPCMAQ scale and good performance on ATM Tasks.

Two of the HLPCMAQ weights yielded equations when regressed onto the ACE measures. Table 8.4-2 shows these results. In all equations, F is significant at the $p < .15$ level.

Table 8.4-2
Results of Stepwise Regression (First Step Only):
HLPCMAQ (3 Weights) as Independent Variables and
ACE Checklist Measures as Dependent Variables+
(n=20)

Equation	Multiple R	% Variance
1.) ACEALL = (-.54) PCONLY + 6.47	.39	15 *
2.) TEAMACE = NE		
3.) XMNITOR = (-1.23) ABSDIF + 3.91	.57	33 ***
4.) INFOEXC = (-.84) PCONLY +8.08	.58	33 ***
5.) WORKMNG = (-.74) ABSDIF + 3.65	.40	16 *
6.) GLOBAL = (-.72) ABSDIF + 3.65	.34	11

+ Levels of significant are: *** $p < .01$, ** $p < .05$, and * $p < .10$.

The above equations also appear to indicate that the more similar the attitude of the two crewmembers regarding HLPCMAQ, the better the aircrew will score on XMINTOR, WORKMNG, and GLOBAL. However, when considering the HLPCMAQ score of only the PC, a more positive score predicts worse performance on ACEALL and INFOEXC. This finding is interpreted to mean that crews perform better if they agree on, and hold similar attitudes

towards, HLPCMAQ, but the PC's HLPCMAQ attitude is insufficient to predict good crew performance. These concepts are congruent with those of effective aircrew coordination.

Two equations developed from the regression equations using the three HLPCMAQ weights to predict simulator performance variables. Table 8.4-3 shows the results.

Table 8.4-3
Results of Stepwise Regression (First Step Only): HLPCMAQ (3 Weights) as Independent Variables and Simulator Performance as Dependent Variables+
(n=20)

Equation	Multiple R	% Variance
1.) NAVTIME = (-2.19) PCANDPI + 55.88	.40	16 *
2.) DEVIATE# = NE		
3.) %OFFCOUR = NE		
4.) WITHIN = NE		
5.) THRT# = NE		
6.) THRTIME = NE		
7.) THRTMAX = NE		
8.) MEANDUR = NE		
9.) ILSRIGHT = (-13.91) ABSDIF + 89.72	.42	18 *

+ Levels of significance are: *** p < .01, ** p < .05, and * p < .10.

The equation developed around the NAVTIME performance measure indicates that when the combination of the PC's and PI's attitude yields a higher HLPCMAQ attitude, the more likely it is that their NAVTIME performance will be better. The equation built around ILSRIGHT indicates that as a crew holds similar attitudes on the HLPCMAQ scale, the percent of ILS steps correctly executed increases. This latter finding again demonstrates that the homogeneity of the crew's attitude positively affects performance.

8.5 Crew Attitude Combinations of GIVEGET Scale to Predict Behavior/Performance

Although the results of the analyses utilizing the three GIVEGET weights did not yield as many equations as the three HLPCMAQ weights, the conclusions are equally as interesting. The results of the regressions of the ATM scales with the three GIVEGET weights can be seen in Table 8.5-1. Note that F is significant at the $p < .15$ level in all equations.

Table 8.5-1
Results of Stepwise Regression (First Step Only):
GIVEGET (3 Weights) as Independent Variables and
ATM Task Measures as Dependent Variables+
(n=20)

Equation	Multiple R	% Variance
1.) ATMALL = (-.27) ABSDIF + 2.56	.33	11
2.) ATM_13 = NE		
3.) ATM_12 = (-.30) ABSDIF + 2.69	.34	11
4.) BIGRADE = (-.57) ABSDIF + 2.56	.39	16 *
5.) TASK1071 = NE		

+ Levels of significance are: *** p < .01, ** p < .05, and * p < .10.

These equations indicate that the more diverse the attitudes of the PC and PI regarding the giving and getting of information, the lower their score will be on the ATM Tasks. These results are consistent with HLPCMAQ scale: the more similar a crew, the better their performance is likely to be. It appears that when using the "logical" scales, the ABSDIF weighting is the most powerful predictor combination for ATM Task performance.

Of the six ACE measures analyzed, only one produced a significant equation with the GIVEGET scale:

$$\text{XMNITOR} = (-.80)\ \text{ABSDIF} + 3.78$$

The multiple R of this equation equals .43, with 18% of the variance explained (F is significant at the $p < .06$ level). This equation, signifying that the more similar a crew's attitude, the better their performance, is congruent with many of the previous findings in this Section.

The three GIVEGET weights yielded more significant equations with the dependent simulator performance variables than with any of the other "logical" scales. Table 8.5-2 shows these equations. In all equations, F is significant at the $p < .15$ level.

Table 8.5-2
Results of Stepwise Regression (First Step Only):
GIVEGET (3 Weights) as Independent Variables and
Simulator Performance as Dependent Variables+
(n=20)

Equation	Multiple R	% Variance
1.) NAVTIME = (-3.98) PCONLY + 52.96	.43	19 *
2.) DEVIATE# = NE		
3.) %OFFCOUR = NE		
4.) WITHIN = .42 PCONLY + (-2.12)	.51	26 **
5.) THRT# = (-1.92) PCONLY + 15.13	.38	14
6.) THRTIME = NE		
7.) THRTMAX = NE		
8.) MEANDUR = NE		
9.) ILSRIGHT = (-15.41) ABSDIF + 92.86	.56	32 **

+ Levels of significance are: *** $p < .01$, ** $p < .05$, and * $p < .10$.

In three of the four equations developed, the PCONLY weight is the most influential of the three combinations. Again, note the inverse nature of many of the performance measures (specifically, NAVTIME, DEVIATE#, %OFFCOUR, THRT#, THRTIME, THRTMAX, and MEANDUR), where lower values denote better performance. The equations built around NAVTIME and THRT#, along with WITHIN, all indicate that performance is improved when the PC has a good attitude about the exchange of mission information (GIVEGET) within a crew. Clearly, the attitude of the PC is an important determinant of successful information exchange.

The equation developed around ILSRIGHT demonstrates that the ABSDIF weight is most predictive of this measure. The GIVEGET-ILSRIGHT relationship seems to be differentiated from the other GIVEGET-performance relationships in this respect.

8.6 Crew Attitude Combinations of CMQALL Scale to Predict Behavior/Performance

The three weights of the CMQALL scale were regressed with the ATM, ACE, and performance measures. One equation, shown below, was developed around the BIGRADE variable:

$$\text{BIGRADE} = (-.93)\ \text{ABSDIF} + 2.58$$

The multiple R was equal to .41, and 17 percent of the variance was explained (F was significant at the $p < .07$ level). This equation shows that the more similar a crew's attitudes, the better their BIGRADE.

One equation, shown below, was developed for the XMNITOR scale:

$$\text{XMNITOR} = (-1.10)\ \text{ABSDIF} + 3.72$$

The multiple R was equal to .38, and 14 percent of the variance was explained (F was significant at the $p < .10$ level). Again, this equation shows that the more similar a crew, the better their performance.

The equations developed using the three weights of the CMQALL and the performance measures are reasonably consistent with results obtained with other scales. Table 8.6-1 shows these results. In all equations, F is significant at the $p < .15$ level.

Table 8.6-1
Results of Stepwise Regression (First Step Only): CMQALL (3 Weights) as Independent Variables and Simulator Performance as Dependent Variables+
(n=20)

Equation	Multiple R	% Variance
1.) NAVTIME = NE		
2.) DEVIATE# = NE		
3.) %OFFCOUR = NE		
4.) WITHIN = NE		
5.) THRT# = (-2.54) PCONLY + 17.82	.35	12
6.) THRTIME = NE		
7.) THRTMAX = NE		
8.) MEANDUR = NE		
9.) ILSRIGHT = (-16.39) ABSDIF + 89.63	.36	13

+ Levels of significance are: *** $p < .01$, ** $p < .05$, and * $p < .10$.

In Table 8.6-1, equations show that the PCONLY weight of the CMQALL scale positively affects THRT# performance. The better the PC's attitude, the fewer the threats encountered. The ILSRIGHT variable is positively affected when the PC and PI have more similar scores on CMQALL.

8.7 Summary

Results presented in this Section clearly demonstrate that various combinations of an aircrew's attitude, as measured by the Army CMAQ, are able to predict performance on ATM Tasks, ACE Checklist, and performance measures. Of note was that the ABSDIF weight, essentially a coefficient of agreement among the two crewmembers, appeared to be the most robust weight. These findings are of critical importance to the understanding of aircrew dynamics.

Section 9.0
Relationships Among the Measures Using the CMAQ "Factor" Scales: Various Crew Combinations

9.1 Introduction

The Army CMAQ "factor" scales comprise four attribute scales: COMMCOR, SHARLEAD, STRESS, and CMAQ34. As previously described in Paragraph 8.1, ten combinations of the CMAQ "factor" scales were weighted and correlated with ATM, ACE, and performance variables. Appendix F shows the bivariate correlation matrix. As was the case for the CMAQ "logical" scales, the PCONLY, PCANDPI, and ABSDIF weights displayed the strongest relationships; therefore, only those combinations were include in these analyses.

Stepwise regression equations were calculated using the ATM, ACE, and performance variables as dependent variables with the PCONLY, PCANDPI, and ABSDIF weights as the independent variables. As discussed in Paragraph 8.1, the probabilities for F-to-enter and F-to-remove from any regression equation were relaxed to the $p < .15$ and $p < .16$ levels, respectively. This permitted development of meaningful stepwise regression equations using the three CMAQ weights with the dependent variables. Also, as previously stated, only the variable which entered on the first step is displayed in the following tables.

The organizational chart for this Section is at Table 9.1-1.

Table 9.1-1
Organizational Chart for Section 9:
Army CMAQ "Factor" Scales

Analysis/Equation	Interpretation	Table(s)
9.2 Crew attitude combinations of COMMCOR Scale to predict behavior/performance	ABSDIF predicts ATM Tasks; ABSDIF and PCONLY predict ACE measures; each weighting enters a performance prediction equation	9.2-1, 9.2-2, 9.2-3
9.3 Crew attitude combinations of SHARLEAD Scale to predict attitude/ performance	Does not predict ATM Task performance; PCONLY predicts several ACE measures; PCONLY and ABSDIF predict several performance measures	9.3-1, 9.3-2
9.4 Crew attitude combinations of STRESS Scale to predict attitude/performance	Does not predict ATM or ACE performance; ABSDIF weight predicts many performance measures	9.4-1
9.5 Crew attitude combinations of CMAQ34 Scale to predict attitude/performance	Does not predict ATM or ACE performance; PCONLY predicts NAVTIME and THRT#; ABSDIF predicts ILSRIGHT	9.5-1

9.2 Crew Attitude Combinations of COMMCOR Scale to Predict Behavior/Performance

The three weights of the COMMCOR scale yielded many regression equations across the ATM, ACE, and performance variables. Four of the five ATM measures yielded equations with the ABSDIF weight entering the stepwise regression equation on the first step. These equations are at Table 9.2-1. Where an equation was developed, F is significant at the $p < .15$ level.

Table 9.2-1
Results of Stepwise Regression (First Step Only):
COMMCOR (3 Weights) as Independent Variables and
ATM Task Measures as Dependent Variables+
(n=20)

Equation	Multiple R	% Variance
1.) ATMALL = (-.51) ABSDIF + 2.64	.43	18 *
2.) ATM_13 = (-.54) ABSDIF + 2.74	.41	17 *
3.) ATM_12 = (-.52) ABSDIF + 2.76	.40	16 *
4.) BIGRADE = (-.88) ABSDIF + 2.64	.41	17 *
5.) TASK1071 = NE		

+ Levels of significance are: *** $p < .01$, ** $p < .05$ and * $p < .10$.

When crewmembers held more similar attitudes (ABSDIF) about communication and coordination (COMMCOR), they tended to receive higher ATM ratings. This finding is similar to those presented in Tables 8.4-1 and 8.5-1 for the HLPCMAQ and GIVEGET "logical" scales. The finding is also in consonance with Table 2.5-3 wherein GIVEGET and HLPCMAQ are postulated to be equivalent to COMMCOR.

Four of the six ACE scales are predicted via two of the three weights of the COMMCOR scale. Table 9.2-2 shows the results of the equations. F is significant at the $p < .15$ level in all equations developed.

Table 9.2-2
Results of Stepwise Regression (First Step Only):
COMMCOR (3 Weights) as Independent Variables and
ACE Scales as Dependent Variables+
(n=20)

Equation	Multiple R	% Variance
1.) ACEALL = (-.76) ABSDIF + 3.68	.38	14 *
2.) TEAMACE = NE		
3.) XMNITOR = (-1.34) ABSDIF + 3.94	.49	24 **
4.) INFOEXC = NE		
5.) WORKMNG = .92 PCONLY + (-2.19)	.41	17 *
6.) GLOBAL = (-1.16) ABSDIF + 3.85	.43	18 *

+ Levels of significance are: *** $p < .01$, ** $p < .05$, and * $p < .10$.

The equations presented in Table 9.2-2 are similar to those presented in Table 8.4-2. In this case, ACEALL, XMNITOR, and GLOBAL measures are best predicted by the ABSDIF weight. In all of these equations, the Beta weight of ABSDIF is negative, meaning that as the difference among crewmembers' COMMCOR attitude decreases, performance improves. It is particularly interesting to note that this is also true for the GLOBAL measure; i.e., the overall performance rating can be improved if crewmembers hold similar attitudes.

The equation developed around the WORKMNG scale indicates that of the three weights used, the PCONLY weight has the most importance for that ACE subscale rating. While the result is statistically significant at only the $p < .10$ level, it appears that the PC's good attitude about COMMCOR can have a positive effect on the crew's performance and, in particular, on establishing and maintaining reasonable workload levels.

Table 9.2-3 shows the equations generated when the COMMCOR scale is entered using the three weights as independent variables and the performance variables as the dependent variables. F is significant at the $p < .15$ level in all equations developed.

Table 9.2-3
Results of Stepwise Regression (First Step Only): COMMCOR (3 Weights) as Independent Variables and Simulator Performance as Dependent Variables+
(n=20)

Equation	Multiple R	% Variance
1.) NAVTIME = (-8.08) PCONLY + 78.03	.62	38 ***
2.) DEVIATE# = (-1.09) PCONLY + 7.96	.44	19 **
3.) %OFFCOUR = (-17.74) PCANDPI + 238.31	.55	30 **
4.) WITHIN = NE		
5.) THRT# = (-2.64) PCONLY +19.79	.36	13
6.) THRTIME = NE		
7.) THRTMAX = NE		
8.) MEANDUR = NE		
9.) ILSRIGHT = (-16.85) ABSDIF + 91.20	.42	18 *

+ Levels of significance are: *** $p < .01$, ** $p < .05$, and * $p < .10$.

As shown by Table 9.2-3, all three different weights enter the equations and have varying levels of predictive value when regressed with the performance variables. All the Beta weights are in the expected direction in relation to the variable being predicted. The equations built around the NAVTIME, DEVIATE#, and THRT# variables indicate that the attitude of the PC regarding COMMCOR has the most positive effect on crew performance. Similarly, the equation built around %OFFCOUR signifies that the more positive both crewmembers scores are on COMMCOR, the lower their %OFFCOUR. The equation built around the ILSRIGHT performance measure indicates that the more similar a crew's attitudes regarding communication and coordination, the better their performance will be on this measure. This latter finding is consistent with the findings of Tables 8.4-3 and 8.5-2, in which ABSDIF was the best predictor of ILSRIGHT on both the HLPCMAQ and GIVEGET scales. The finding also provides additional supporting evidence to substantiate the linkages depicted in Table 2.5-3.

9.3 Crew Attitude Combinations of SHARLEAD Scale to Predict Attitude/Performance

When the SHARLEAD scale was entered into regression equations using the three weights as the independent variables with ATM, ACE, and performance variables as the dependent

variables, the results again varied with the type of independent measure. No equations could be developed for the ATM scales. Two of the six ACE measures yielded equations. The ACE equations are at Table 9.3-1. In all equations, F is significant at the $p < .15$ level.

Table 9.3-1
Results of Stepwise Regression (First Step Only): SHARLEAD (3 Weights) as Independent Variables and ACE Checklist Measures as Dependent Variables+
(n=20)

Equation	Multiple R	% Variance
1.) ACEALL = NE		
2.) TEAMACE = NE		
3.) XMNITOR = (-.52) PCONLY + 6.24	.35	12
4.) INFOEXC = (-.45) PCONLY + 5.70	.39	15 *
5.) WORKMNG = NE		
6.) GLOBAL = NE		

+ Levels of significance are: *** $p < .01$, *** $p < .05$, and * $p < .10$.

The equations built around the XMNITOR and INFOEXC measures indicate that there is a relationship between the PC's SHARLEAD attitude and crew performance. In these two equations, it appears that the more positive the PCONLY attitude is, the lower the ratings on XMNITOR and INFOEXC; i.e., a positive PCONLY attitude regarding the sharing of leadership may have a negative impact on performance. This result has low statistical significance, in itself a favorable condition since it is a difficult relationship to explain and it is inconsistent with the principles of aircrew coordination. However, it may indicate that a PC with a low score on SHARLEAD is an autocratic or authoritarian leader, a trait which for some unknown reason may be helpful in improving XMNINTOR and INFOEXC.

The results of the regression equations with the three weights of the SHARLEAD scales and the performance variables resulted in the equations at Table 9.3-2. In all equations, F is significant at the $p < .15$ level.

Table 9.3-2
Results of Stepwise Regression (First Step Only): SHARLEAD (3 Weights) as Independent Variables and Simulator Performance as Dependent Variables+
(n=20)

Equation	Multiple R	% Variance
1.) NAVTIME = (-2.03) PCANDPI + 53.67	.40	16 *
2.) DEVIATE# = NE		
3.) %OFFCOUR = NE		
4.) WITHIN = NE		
5.) THRT# = (-1.83) PCONLY + 14.74	.40	16 *
6.) THRTIME = NE		
7.) THRTMAX = NE		
8.) MEANDUR = NE		
9.) ILSRIGHT = (-10.00) PCONLY + 140.51	.43	18 *

+ Levels of significance are: *** $p < .01$, ** $p < .05$, and * $p < .10$.

The equation built around NAVTIME indicates that the "better" the combined attitudes of the PC and PI are, the better NAVTIME will be; i.e., performance improves.

The THRT# equation indicates that, as has been seen in other regression equations using performance measures as the dependent variables, the PC's positive attitude is positively related to good performance. This does not mean that the PC is not performing as the leader of the crew; but, rather how the PC *feels* about these concepts apparently influences the atmosphere and performance of the crew.

The equation developed around the ILSRIGHT measure indicates that the PC's attitude can have a negative effect on the crew's ILSRIGHT performance, thereby contradicting the equation built around THRT#. This finding is also different from all previous equations developed around the ILSRIGHT measure. A plausible explanation may be that, as previously determined on other attitude scales, the primary determinant on ILSRIGHT performance is the extent to which the crewmembers agree (ABSDIF). In the present case, a negative relationship with the PCONLY weight lends credence to the "crew agreement" finding, i.e, that the crew's combined agreement on an attitude is most important; the PC's attitude alone is insufficient.

In summary, the SHARLEAD factor provided some "other than expected" results. One explanation may be that for Army personnel the idea of "sharing responsbility for leadership" is anathema to their perceptions of, and training for, leadership responsibility. This idea regarding the PC's leadership responsibility may come, in part, from AR 95-1 which dictates that the PC has absolute authority in the cockpit. Aviators who reject the notion of shared leadership may be successful in terms of at least some of the measures available in this study.

9.4 Crew Attitude Combinations of STRESS Scale to Predict Attitude/Performance

The STRESS CMAQ scales were weighted in the three combinations and regressed with the ATM, ACE and performance measures. No equations were derived for the ATM or ACE measures. The equations for the performance variables are at Table 9.4-1. F is significant at the $p < .15$ level in all equations.

Table 9.4-1
Results of Stepwise Regression (First Step Only): STRESS (3 Weights) as Independent Variables and Simulator Performance as Dependent Variables+
(n=20)

Equation	Multiple R	% Variance
1.) NAVTIME = 2.18 ABSDIF + 28.11	.34	12
2.) DEVIATE# = NE		
3.) %OFFCOUR = NE		
4.) WITHIN = (-.26) ABSDIF + .52	.46	21 **
5.) THRT# = 1.55 ABSDIF + 2.65	.45	20 **
6.) THRTIME = 22.33 ABSDIF + 31.91	.44	19 **
7.) THRTMAX = 6.55 ABSDIF + 13.96	.41	17 **
8.) MEANDUR = NE		
9.) ILSRIGHT = NE		

+ Levels of significance are: *** $p < .01$, ** $p < .05$, and * $p < .10$.

Table 9.4-1 demonstrates that ABSDIF is the best weighting to predict the performance variables when using the STRESS scale. When crewmembers hold similar attitudes regarding the recognition of stressor effects, the performance of the crew improves (NAVTIME, THRT#, and THRTMAX are inverse variables, with good performance noted by lower scores). These results demonstrate that the attitude of recognizing, and presumably dealing with stressor effects requires a different type of aircrew working relationship than either COMCORR or SHARLEAD. Note that prediction of simulator performance using the "logical" scales in Section 8 resulted in similar crew attitude weights appearing across four of the five "logical" scales. In the case of the "factor" scales, the "best" weights are different depending on the "factor" scale used in predicting performance. This finding points to the conclusion that the "factor" scales are most likely assessing different attitudes.

9.5 Crew Attitude Combinations of CMAQ34 Scale to Predict Attitude/Performance

Using the three different weights, the CMAQ34 scale was regressed with the ATM, ACE, and performance measures. No equations were developed for either ATM or ACE measures. Table 9.5-1 shows the results of stepwise regression with the three weights of CMAQ34 and the performance variables. F is significant at the $p < .15$ level in all equations.

Table 9.5-1
Results of Stepwise Regression (First Step Only): CMAQ34 (3 Weights) as Independent Variables and Simulator Performance as Dependent Variables+
(n=20)

Equation	Multiple R	% Variance
1.) NAVTIME = (-4.35) PCONLY + 54.32	.39	15 *
2.) DEVIATE# = NE		
3.) %OFFCOUR = NE		
4.) WITHIN = NE		
5.) THRT# = (-2.43) PCONLY + 17.66	.39	15 *
6.) THRTIME = NE		
7.) THRTMAX = NE		
8.) MEANDUR = NE		
9.) ILSRIGHT = (-14.97) ABSDIF + 90.05	.38	15

+ Levels of significance are: *** $p < .01$, ** $p < .05$, and * $p < .10$.

As was seen in the COMMCOR and SHARLEAD analyses, Table 9.5-1 demonstrates that PCONLY appears to be the best predictor of NAVTIME and the THRT#. The negative coefficients indicate that the PC's positive attitude serves to improve crew performance on these measures; i.e., the "better" the PC's attitude, the better will be the crew's performance as determined by NAVTIME and THRT#.

The equation built around ILSRIGHT, while only marginally statistically significant, is consistent with several other equations developed around ILSRIGHT. It shows that the more similar the attitudes of the crewmembers, the better their performance will be on an ILS approach.

9.6 Summary

The CMAQ "factor" scales, in the various weights, can predict ATM, ACE and performance measures. Comparing these results with those found in Section 8, it appears that using the "factor" scales results in a greater number of, and more significant predictions of, behavior or performance. It was also noted that the best weighting combination of the "factor" scales varied depending on which scale was used to predict performance. This finding points to the conclusion that the three "factor" scales are assessing different attitudes; perhaps more so than the "logical" scales are able to do.

All three crew attitude weights provide insight into the manner in which attitude affects performance. The weight that appeared to be the most powerful predictor was ABSDIF since it appeared in the most equations. ABSDIF also consistently predicted behavior or performance in a "correct," easily explained manner. On the other hand, PCONLY and PCANDPI yielded inconsistent and often difficult to explain results. The meaning of this finding is that it is important that crewmembers agree. It does not mean that crewmembers need to have a "good" attitude as measured by the CMAQ or its subscales; simply that they must have similar views.

In summary, it appears that the "best" organization of the Army CMAQ is the "factor" organization; and the "best" weighting of crew attitudes is the ABSDIF.

Section 10.0 - Summary and Conclusions

10.1 General

The previous Sections of this report presented the findings resulting from the analysis of aircrew attitudinal, behavioral, and performance data collected during the Spring and Summer of 1990. Many findings were discussed, and several hypotheses previously thought to be true logically were empirically proven to be so. Beginning with Paragraph 10.2, a compilation of the actions taken and findings made, collected by Section number is presented. Following the summaries, several patterns discerned during the analyses are presented, and recommendations are made for continued research.

10.2 Section 2: Properties of the Army CMAQ

* Re-evaluated the structure of the Army CMAQ "logical" scales. "Give Information" and "Get Information" were combined into one scale similar in format to the "Provide/Accept Help" scale previously developed. Redefined "Values Crew" as "Values Teamwork."

* Uniquely placed all Army CMAQ items into subscales.

* Computed reliabilities for the Army CMAQ "logical" scales using Cronbach's Alpha (range from .51 to .78), split-half (range from .33 to .66), and test-retest (range from .40 to .81) algorithms. Reliabilities fell in the "acceptable" range.

* Performed factor analysis on the CMAQ. Developed factor scales based on three defined criteria. Renamed Factor 2 to be "Shared Leadership." Developed linkage chart for the "logical" and "factor" scales.

* Computed reliabilities for the Army CMAQ "factor" scales using Cronbach's Alpha for the 80 aviators (range from .67 to .81), Cronbach's Alpha for the 40 aviators (range from .69 to .85), and split-half (range from .49 to .68) algorithms. Better reliabilities were obtained for the CMAQ "factor" scales than for the "logical" scales.

* Compared selected CMAQ responses of high and low quality (as determined by IP quality ratings) and high and low performing (as determined by performance on the ATMALL scale) Army aviators to the ratings, as documented by Helmreich et al. (1986), of "superior" commercial aviators. Comparison revealed Army aviators hold somewhat similar CMAQ attitudes; however --

    o Army aviators differ from commercial aviators on certain items; e.g., "My decision making ability is as good in emergencies as in routine mission situations." Army aviators tend to agree with this statement; "superior" commercial aviators do not. Agreement with this item contradicts the principles of good aircrew coordination.

- o Several items showed significant differences in the responses between high and low "quality" Army aviators, and between high and low "performing" Army aviators. Generally, the direction of the difference was in the expected direction, i.e., better "quality" or "performing" aviators tended to agree more with a principle of aircrew coordination than the lesser "quality" or "performing" Army aviators.

10.3 Section 3: Properties of the ACE Checklist

* Uniquely placed ACE items into subscales.

* Computed reliabilities for five ACE subscales. Cronbach's Alphas for the subscales ranged from .66 to .90; Cronbach's Alpha for the ACE is .93. Reliability coefficients for the ACE are high.

* Performed factor analysis on the ACE data. ACE "factor analytic" scales appeared to measure similar attributes as the ACE "logic-based" scales. The three scales of the factor analytic model were described as "communication and group climate," "workload and performance management," and "cross monitoring by crewmembers."

* Rejected the ACE "factor analytic" scales from incorporation into further ACE analyses for reasons detailed in Paragraph 3.4.

10.4 Section 4: Properties of the Revised ATM Tasks

* Proved, through reliability analysis, that the ATM scales are highly reliable. Since missing data are a problem with the data base, both Cronbach's Alpha and the Spearman-Brown prophecy formula were used to compute reliability coefficients. ATM Task subscale reliabilities ranged from .85 to .90.

* Discovered, through analysis of the use of Task 1071 Standards, that IPs tended to use certain Task 1071 Standards more than others. In particular, Standards 6 and 8 were used most often, while standards 4, 3, 2, 1, and 9 were also frequently used. Referencing Task 1071 within other ATM Task Standards was found to be efficient and informative.

* Found that Standard 10 was not utilized because aircrews did not avail themselves of the opportunity to accomplish their own post-flight debriefing, there was little time during the simulator session to critique, and because post-flight debriefings may not be a part of the "culture" among unit aviators participating in the testbed. Nevertheless, IP-raters thought Standard 10 to be an important aircrew coordination-related activity and should be kept as a Standard.

* Recommended the word "conflict" not be used in future Standards. Instead, the phrase "difference of opinion" should be used. "Conflict" was originally used in a psychological manner to represent a "difference of opinion." To Army personnel, the word "conflict" is interpreted to mean a physical fight or military action.

10.5 Section 5: Properties of the Performance Measures

* Presented only an overview of the performance variables in this Section. DRC assumed that Anacapa provided ARIARDA with a report discussing the construction and properties of the performance variables.

* Presented analyses in subsequent Sections showing that the performance variables were effective in discriminating between high and low performing aircrews. While no analyses of the internal properties of the performance variables were undertaken, this finding substantiates the objectivity of the performance variables and an underlying high reliability.

10.6 Section 6: Relationships Among the Measures

NOTE: Sections 6 through 9 focus on various regression equations computed to determine the relationships among the measures used in this study. Sections 6 and 7 incorporate 40 CMAQ "observations" (or scores); Sections 8 and 9 incorporate 20 CMAQ observations representing a combination of an aircrew's CMAQ score.

Section 6 shows analyses performed to demonstrate the relationships among the ATM, ACE, performance measures, and CMAQ "logical" scales. Findings were:

* ACE subscales are highly predictive of ATM performance (explaining as much as 66% of the variance).

* ACE subscales are moderately predictive of the performance variables (explaining as much as 46% of the variance in the navigation-related performance variables).

* CMAQ "logical" scales are not predictive of ATM performance, but appear to have a small effect on aircrew coordination-related ATM tasks.

* CMAQ "logical" scales are not predictive of ACE performance.

* CMAQ "logical" scales are not predictive of the performance variables.

* The combination of CMAQ and ACE subscales has very good predictive power of the ATM scales (explaining as much as 71% of the variance in ATM Task performance).

* The combination of CMAQ subscales, ATMALL, and ACE subscales is a very good predictor of performance measures (explaining as much as 60% of the variance in the navigation-related performance variables).

* When the CMAQ "logical" scales, ATMALL, and the ACE subscales are entered into stepwise regression equations, at least one subscale from each measure showed itself to be predictive of a performance measure. Of particular note is the fact that an attitude subscale entered a stepwise regression indicating its significance.

10.7 Section 7: Relationships Among the Measures: CMAQ "Factor" Scales

Section 7 focused only on the relationships of the (n=40) CMAQ "factor" scales with the ATM Tasks, ACE Checklist, and performance variables. Findings were:

* CMAQ "factor" scales have insignificant predictive value in determining ATM performance.

* CMAQ "factor" scales are not predictive of ACE performance.

* When the CMAQ "factor" scales and ACE subscales are both regressed with the ATM scales, the results are very similar to those found when the CMAQ "logical" scales are utilized.

* A combination of CMAQ34 and ACEALL are strong predictors of ATM Task performance (explaining as much as 67% of the variance in the ATM scales). These results are nearly identical to those using CMQALL and ACEALL to predict ATM Task performance.

* The CMAQ "factor" scales do have predictive value when regressed with the performance variables, demonstrating an empirical link between attitudes and performance. Two of the navigation-related performance variables are significantly predicted (explaining 17% and 20% of the variance).

* When the combination of CMAQ "factor" scales, ATMALL, and ACE subscales are regressed with the performance variables, the results are similar to the results utilizing the "logical" scales. However, the use of the CMAQ "factor" scales versus the "logical" scales results in a greater number of statistically significant equations being developed.

* Sections 6 and 7 demonstrate that a measurable link exists between attitudes (as determined by the Army CMAQ) and performance.

10.8 Section 8: Relationships Among the Measures Using the CMAQ "Logical" Scales: Various Crew Combinations

Sections 6 and 7 proved that a statistical, measurable relationship exists between attitudes and performance; therefore, Sections 8 and 9 investigated the hypothesis that some combination of a crew's score with respect to attitudes would be a better predictor of performance. Ten combinations of crew scores were developed and correlated with ATM, ACE, and performance measures. Three of the combinations, PCONLY, PCANDPI, and ABSDIF were selected for further examination based on their correlations with the other measures. In Section 8, the CMAQ "logical" scales were entered into the combinations; Section 9 used the CMAQ "factor" scales. Findings were that when crew attitude combinations were computed for:

* **TEAMCMAQ**: No predictive equations were developed.

* **CREWFAL**: PCONLY negatively predicted THRTMAX; ABSDIF predicted TASK1071, the only measure of both "logical" and "factor" CMAQ scales to predict this ATM Task.

* **HLPCMAQ**: ABSDIF consistently predicted ATM Task measures; PCONLY or ABSDIF predicted several ACE measures; PCANDPI predicted NAVTIME; ABSDIF predicted ILSRIGHT.

* **GIVEGET**: ABSDIF predicted three of the five ATM Task measures and the ACE subscale, XMNITOR; either PCONLY or ABSDIF predicted several performance variables.

* **CMQALL**: ABSDIF predicted BIGRADE, XMNITOR, and ILSRIGHT; PCONLY predicted THRT#.

10.9 Section 9: Relationships Among the Measures Using the CMAQ "Factor" Scales: Various Crew Combinations

Section 9 focused on combinations of aircrew attitudes to assess the relationship between attitudes and behavior/performance. In Section 9, the CMAQ "factor" scales, weighted via combinations of aircrew CMAQ scores, were entered into the regression equations used in Section 8. Findings were that when crew attitude combination scores were computed for:

* **COMMCOR**: ABSDIF best predicted ATM Tasks; ABSDIF and PCONLY best predicted the ACE measures; each of the three weights entered into an equation as the best predictor of a performance variable. These results were similar to those obtained for the HLPCMAQ and GIVEGET "logical" scales.

* **SHARLEAD**: No predictive equations were developed for ATM Tasks; PCONLY predicted several ACE measures; ABSDIF and PCONLY predicted many of the performance measure variables.

NOTE: The equations built around the XMNITOR and INFOEXC measures indicate that there is a relationship between the PC's SHARLEAD attitude and crew performance. In these two equations, it appears that the more positive the PCONLY attitude is, the *lower* the ratings on XMNITOR and INFOEXC; i.e., a positive PCONLY attitude regarding the sharing of leadership may have a negative impact on performance. It may indicate that a PC with a low score on SHARLEAD is an autocratic or authoritarian leader, traits which for some unknown reason may be helpful in improving XMNITOR and INFOEXC.

* **STRESS**: no equations were developed for ATM or ACE measures; ABSDIF predicted many performance variables.

* **CMAQ34**: no equations were developed for ATM or ACE measures; PCONLY predicted NAVTIME and THRT#; ABSDIF predicted ILSRIGHT.

Several discernable patterns evolved during the Section 9 analysis of the "factor" scales:

* All three crew attitude weights (PCONLY, PCANDPI, ABSDIF) provided insight into the manner in which attitude affects performance. The weight that appeared to be the most powerful predictor was ABSDIF. ABSDIF consistently predicted behavior or performance in a "correct," easily explained manner. PCONLY and PCANDPI yielded inconsistent, often difficult to explain results.

* The "logical" CMAQ scales, HLPCMAQ and GIVEGET, perform in a manner similar to the "factor" scale COMMCOR. This reinforces the concept that the "logical" and "factor" scales are aligned as described in Table 2.5-3.

* Certain performance variables tend to act in a similar manner. For example, the variables NAVTIME, DEVIATE#, and %OFFCOUR -- all navigation-related -- tend to behave similarly. This could also be concluded for the THRT#, THRTMAX, and THRTIME which are all threat-related variables. ILSRIGHT, an instrument flight-related variable, correlates differently with the other measures; i.e., inconsistently related to various scales or weights, but often having a significant relationship to at least one aircrew attitude.

* The SHARLEAD factor provided "other than expected" results. One explanation may be that for Army personnel, the idea of "sharing responsibility for leadership" is anathema to their perceptions of, and training for, leadership. It appears that aviators who reject the notion of shared leadership may be successful in terms of at least some of the measures available in this study.

* All CMAQ "factor" scales, with the exception of CMAQ34, behave somewhat differently from one another, lending credibility to the finding that they measure different attributes; i.e., each of the three scales seems to measure unique attitudinal dimensions.

* Conversely, the CMAQ "logical" scales are inconsistent in depicting the attitude → behavior/performance relationship. TEAMCMAQ appears to be the weakest subscale; CREWFAL also appears to be relatively weak. The GIVEGET and HLPCMAQ scales are more robust, but the results of these analyses are similar to one another and similar to the COMMCOR "factor" scale.

10.10 Answers to the Research Questions

Ten research questions were posed in Paragraph 6.1. The questions and their answers are provided below. Note that the "variance explained" statements following each answer are taken from various tables, scales/subscales, and crew attitude combinations. Where shown, for the % of Variance column, *** $p < .01$; ** $p < .05$; * $p < .10$.

Question 1. What is the relationship between the two measures of crew behavior (ACE Checklist and ATM Tasks)?

Answer 1. The two behavior measures are strongly related (as much as 66% of the variance is explained).

Example 1. From Table 6.2-1

	Multiple R	% of Variance
ATM_13 = .21 WORKMNG + .21 XMNITOR + (-.19) INFOEXC + .21 TEAMACE + .96	.81	66% ***

Question 2. What is the relationship between crew coordination behaviors (ACE Checklist) and Mission Performance?

Answer 2. Behavior and Mission Performance are related (as much as 46% of the variance is explained).

Example 2. From Table 6.6-1

	Multiple R	% of Variance
NAVTIME = (-4.27) WORKMNG + 1.97 XMNITOR + .74 INFOEXC + (-1.72) TEAMACE + 41.55	.67	46% **

Question 3. What is the relationship between crew behaviors (ATM Tasks) and Mission Performance?

Answer 3. Behavior and Mission Performance are related (as much as 27% of the variance is explained).

Example 3. From Table 6.9-2

```
                                          Multiple R    % of Variance
DEVIATE# = (-1.15) ATMALL + 4.24             .52           27% ***
```

Question 4. What is the relationship between the combined effect of crew coordination behaviors (ACE Checklist + ATM Tasks) and Mission Performance?

Answer 4. The combined effect of the crew coordination behaviors is highly related to Mission Performance (as much as 50% of the variance is explained).

Example 4. New equation, no reference - "forced entry," (n=20)

```
                                          Multiple R    % of Variance
DEVIATE# = (-.40) WORKMNG + (-1.30) ATMALL +
           (-.64) INFOEXC + .65 XMNITOR +
           .19 TEAMACE + 5.10                .71           50 *
```

Question 5. Which organization of the Army CMAQ, "logical" or "factor," is better?

Answer 5. The "factor" organization is better. Reliability coefficients are higher than those of the "logical" scales; more significant relationships (equations) are depicted when using the "factor" organization; and the three "factor" scales act differently from one another when correlated with external variables.

Question 6. What *combination* of crewmember attitudes, as measured by the Army CMAQ, best demonstrates relationships between crew attitude and crew coordination behaviors/Mission Performance?

Answer 6. The absolute difference (ABSDIF), which is essentially a coefficient of agreement between the two crewmembers, is best. As the crewmembers' scores on an Army CMAQ attitude dimension become more similar, crew coordination behavior and Mission Performance tend to improve.

NOTE: To more precisely answer Questions 7-10, new equations were computed utilizing the three Army CMAQ "factor" scales (COMMCOR, SHARLEAD and STRESS) weighted by ABSDIF.

Question 7. What is the relationship between attitudes toward crew coordination (Army CMAQ) and crew coordination behaviors (ACE Checklist)?

Answer 7. Attitude and behavior are related (as much as 28% of the variance is explained).

Example 7. New equation, no reference - "forced entry," (n=20), ABSDIF weight

	Multiple R	% of Variance
XMNITOR = .22 STRESS + (-1.28) COMMCOR + (-.16) SHARLEAD + 3.82	.53	28%

Question 8. What is the relationship between crew coordination attitudes (Army CMAQ) and crew coordination behaviors (ATM Tasks)?

Answer 8. Attitude and behavior are related (as much as 20% of the variance is explained).

Example 8. New equation, no reference - "forced entry," (n=20), ABSDIF weight

	Multiple R	% of Variance
ATM_13 = (-.01) STRESS + (-.51) COMMCOR + (-.12) SHARLEAD + 2.84	.44	20%

Question 9. What is the relationship between crew coordination attitudes (Army CMAQ) and Mission Performance?

Answer 9. Attitudes and Mission Performance are related (as much as 32% of the variance is explained).

Example 9. New equation, no reference - "forced entry," (n=20), ABSDIF weight

	Multiple R	% of Variance
THRTMAX = 7.01 STRESS + 9.80 COMMCOR + (-7.88) SHARLEAD + 14.28	.56	32%

Question 10. What is the relationship between the combined effect of crew coordination attitudes and behaviors (Army CMAQ + ACE Checklist + ATM Tasks) and Mission Performance?

Answer 10. The combined effect of the crew coordination measures is strongly related to mission performance (as much as 65% of the variance is explained).

Example 10a. New equation, no reference - "forced entry," (n=20), ABSDIF weight

	Multiple R	% of Variance
NAVTIME = (-1.47) ATMALL + 2.59 STRESS + 1.49 SHARLEAD + (-5.67) COMMCOR + 1.24 INFOEXC + (-4.94) WORKMNG + 1.44 TEAMACE + (-.69) XMNITOR + 42.39	.80	65%

Example 10b. New equation, no reference - "stepwise entry," (n=20), ABSDIF weight

	Multiple R	% of Variance
NAVTIME = (-4.14) WORKMNG + 2.19 STRESS + (-4.21) COMMCOR + 43.79	.76	57% ***

10.11 Discussion and Recommendations

* The CMAQ "factor" scales should be used in future studies. Any improvements or revisions made to the Army CMAQ should be made with the underlying "factor" structure in mind.

* The finding that *crewmember agreement on attitude dimensions is a predictor of performance* needs additional investigation to more fully understand this relationship. This concept is congruent with past research that focuses on intracrew "familiarity" and "shared mental models." Examples of this research can be found in Chidester, et al. (1990), Kanki, et al. (1989a and 1989b), Orasanu (1990), and Thorsden, et al. (1990). These researchers, however, focused primarily on operations-relevant interactions. The

importance of the present finding is that shared mental models may well extend to attitudes and perhaps even personality as well. The result of this finding may be that if we combine crews who view the world similarly and think (and behave) in ways that are expected by their fellow crewmembers, performance (and *ipso facto*, safety) is enhanced.

* To take advantage of the principle that "familiarity and/or agreement breeds good performance," the Army should take steps to indoctrinate aviators to value good crew coordination. Over the last decade there has been much research to substantiate the concept that good crew coordination improves performance (cf. Povenmire, et al. (1989), Helmreich & Foushee (1988) and Chidester et al. (1990)). There is also an abundance of evidence gleaned from accident investigations showing that a lack of effective cockpit resource management/aircrew coordination has led to catastrophic results.

  NOTE: The "agreement" finding discussed in the two preceding points could be interpreted to mean that a bad attitude is tolerable as long as both crewmembers share it. But this is a faulty interpretation. For example, Army aviators tend to agree with the statement, "My decision making ability is as good in emergencies as in routine mission situations." This type of thinking is potentially quite dangerous; it could lead to a false sense of over-confidence in one's individual abilities and thus lead a pilot into ignoring (or not soliciting) input from his crew during critical maneuvers or situations. If aviators were trained in the principles of aircrew coordination, they would 1) hold attitudes similar to one another's, and 2) hold attitudes lending themselves to aviation safety.

* Given that a close relationship exists between the ACE Checklist and ATM Task measures; i.e., they are both behavior ratings and they are both highly correlated with mission performance, the Army should consider integrating the ACE Checklist into the APART program. The findings in this report support DRC's contention that *both* measures are important. The ATM Tasks measure fine-grained, task-oriented behavior; the ACE Checklist measures an aircrew's ability to integrate a variety of human factors principles into the cockpit milieu. A two-perspective evaluation scheme utilizing the two measures would capture a more realistic spectrum of aviator/crew performance.

  NOTE: As a result of the efficacy of the ACE Checklist demonstrated by the DRC/ARIARDA work, American Airlines (Treadway & Chidester, 1991, personal communication) is considering integrating a task similar to Task 1071 into their maneuver/procedures (the commercial corollary to ATM Tasks) based on the ACE Checklist format. This approach exemplifies the recommendation made here.

* Implications for instruction:

  o Organizing instruction around the concepts embodied in the RICS Model proposed in the <u>Development of Measures</u> technical report appears warranted.

- o The CMAQ "factor" dimensions should be used as organizers for teaching attitudes.

- o The ACE dimensions should be useful instructional concepts. They are related to performance.

- o Incorporating aircrew coordination considerations into the way that ATM Tasks are taught is highly recommended.

* Implications for flight training candidate and crew selection:

  - o The U.S. Army Aviation Center (USAAVNC) conducts an Initial Entry Rotary Wing (IERW) course of instruction relying on a Multi-Track (MT) concept. Using the IERW-MT concept, students are placed in either the UH-1, OH-58, AH-1, or UH-60 aircraft at Training Day (TD) 100. The placement decision is partially based on an ARIARDA-designed placement battery. One instrument used as part of the IERW-MT placement battery is a version of the NASA/UT CMAQ. That version, and the associated selection algorithms, should be updated to reflect the findings of this report. It is likely that better selection algorithms and more effective decisions would be made using an improved Army CMAQ.

  - o Consideration should be given to pairing crews based on familiarity. Conversely, paired aviators who are unfamiliar with one another should be specifically taught that there is an adjustment period. They should plan on a period of time (perhaps two missions, as implied by the NASA-Ames studies) where they are flying at less than optimal performance and at a reduced safety margin.

  - o Consideration should be given to the future development of computer software for the purpose of determining "acceptable" pilots to fly with unit PICs. Such acceptability would be based on the ABSDIF finding as it relates to certain key attitudes found as a result of administering a CMAQ-type instrument to all unit aviators.

* Follow-on studies to this report should have a larger sample size.

* There is an underlying factor structure to the ACE Checklist. This factor structure should be determined on a larger sample than was available for the testbed.

* Inter-rater reliability should be determined for both the ACE Checklist and the ATM Tasks (Modified Gradeslips). This study could be accomplished by using the videotapes of the twenty testbed simulator sessions. A problem noted in the testbed data is that there may have been a rater halo effect in operation. For example, Crew 20 was rated high on the ACE Checklist and ATM Tasks, but their simulator mission performance was not good.

* A follow-on to this study (or an exploratory study using the current data) could profitably investigate the relationship of the ACE Checklist, ATM Tasks, and Army CMAQ with three *categories* (or, "macro"-variables) of mission performance: navigation-related, threat-related and instrument flight-related. It is thought that navigation and instrument flight are especially aircrew coordination-intensive.

* Relationships of attitude → behavior → performance using all *three* CMAQ "factor" scales weighted with the ABSDIF combination could be investigated more thoroughly than was reported here. Resource constraints prohibited the pursuit of additional statistical investigations.

* The attitude → behavior → performance linkage should be investigated further. It is thought that the linkage may change based on the problem context or operational environment. For example, were the mission in an actual instead of a simulated environment, would performance and its link to the other measures have been different?

* Attitudes and skills change over time and are greatly influenced by an individual's experience. The change should be measured. Several questions could then be answered. For example:

  - What is the interaction of attitudes and skills?
  - Do high-time aviators tend to become more or less enthusiastic about, and skilled at, aircrew coordination?
  - Optimally, when should refresher training in aircrew coordination skills take place?
  - Does combat experience affect attitudes or skills related to aircrew coordination?

* Other worthwhile research questions can be asked regarding the Army CMAQ. For example:

  - To what extent does a "social desirability effect" influence CMAQ responses?
  - Would other measures of attitudes or personality serve as better predictors of aircrew coordination-related behaviors?

* Finally, the Fort Campbell testbed represents the initial use of the measures and procedures developed for the ARIARDA crew effectiveness project. The testbed was designed as a try-out to fine-tune the present measures and procedures in preparation for a larger, more refined testbed incorporating improved instruments and procedures. The Army is now well-positioned to conduct such a follow-on testbed -- a testbed which, if the present report is any indication, should produce enhanced empirical definitions of the attitude → behavior → performance relationships introduced during this study.

References

Chidester, T.R., Kanki, B.G., Foushee, H.C., Dickinson, C.L., and Bowles, S.V. (1990). Personality Factors in Flight Operations: Volume I. Leader Characteristics and Crew Performance in a Full-Mission Simulation. (NASA Technical Memorandum 102259). Moffett Field, CA: NASA-Ames Research Center.

Gregorich, S.E., Helmreich, R.L., and Wilhelm, J.A. (1990). The Structure of Cockpit Management Attitudes. Journal of Applied Psychology, 75, 682-690.

Helmreich, R.L., Foushee, H.C., Benson, R., and Russini, W. (1986). Cockpit Resource Management: Exploring the Attitude-Performance Linkage. Aviation, Space, and Environmental Medicine, 57, 1198-1200.

Helmreich, R.L. and Foushee, H.C. (1988). Group interaction and flight performance. In: Weiner, E.L., and Nagel, D.C. (Eds.) Human Factors in Aviation. San Diego, CA: Academic Press.

Kanki, B.G., Lozito, S., Foushee, H.C. (1989a). Communication Indices of Crew Communication. Aviation, Space, and Environmental Medicine, 60, 56-60.

Kanki, B.G., Foushee, H.C. (1989b). Communication as Group Process Mediator of Aircrew Performance. Aviation, Space, and Environmental Medicine, 60, 402-410.

Orasanu, J.M. (1990). Shared Mental Models and Crew Decision Making. (CSL Report 46). Princeton, NJ: Cognitive Science Laboratory, Princeton University.

Povenmire, H.K., Rockway, M.R., Bunecke, J.L., and Patton, M.W. (1989). Cockpit resource management skills enhance combat mission performance in a B-52 simulator. In Proceedings of the 5th International Symposium on Aviation Psychology, 489-494.

Thorsden, M.L., Klein, G.A., and Wolf, S. (1990). Observing Team Coordination Within Army Rotary-Wing Aircraft Crews. (KATR90C2-90-05-Z). Yellow Springs, OH: Klein Associates, Inc.

APPENDIX A

Aircrew Coordination Measures

APPENDIX A.1

Army CMAQ

Army Aviation Crewmember Questionnaire

Rev. 4

I. Background Information

(Please complete the following information regarding your personal experiences and current status.)

1. Aviation Experience (Flt. Hrs.)

2. Date *(day/mo/yr)* ____________________

	Lifetime Flying Experience		Experience over last 6 months	
	All Conditions	NV Devices (e.g., NVG)	All Conditions	NV Devices (e.g. NVG)
a. UH-60 hrs.	________	________	________	________
b. R/W hrs.	________	________	________	________
c. Fixed Wing hrs.	________	________	________	________

3. Current Rank ____________________

4. Current Unit (Co/Bn/Rgt) ____________________

5. Time in Current Unit (months) ____________________

6. Current Aviator Readiness Level (RL) 1 2 3 *(circle one number)*

7. Current primary duty assignment in unit *(check one)*:

   IP_____ SP_____ UT_____ IFE_____ MTP_____ Aviator_____ Other_____

8. Are you flight lead qualified *(circle one)*: Yes No

9. Have you had Aircrew Coordination Training? Y or N *(circle one: if yes, answer below .)*

   Describe ACT training experiences: Course title, location of training, approximate date, # of hours of instruction, quality of course.

   a. Experience #1: ____________________

   ____

   ____

   b. Experience #2: ____________________

   ____

   ____

10. Cross-Indexing Code (*Note:* Your responses to this form will not be used to evaluate you and will not become a part of any permanent record relating to you. An individual identifier is necessary since you will be undertaking other related activities and we simply need a "cross-index" number to keep track of the participants in this research.)

    Social Security #: ____________________

Rev. 4

II. Opinion Survey

(Please circle the number on the agree-disagree dimension that best reflects your personal attitude toward each statement. There are no "right" or "wrong" answers. We are simply asking for your honest opinions.)

	Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree
1. Crewmembers should avoid disagreeing with others because conflicts create tension and reduce crew effectiveness.	1	2	3	4	5	6	7
2. Crewmembers should feel obligated to mention their own psychological stress or physical problems to other crewmembers before or during a mission.	1	2	3	4	5	6	7
3. It is important to comment about the procedures and techniques of other crewmembers.	1	2	3	4	5	6	7
4. Pilots-in-command should not dictate flight techniques to other crewmembers.	1	2	3	4	5	6	7
5. Casual social conversation during periods of low workload can improve crew coordination.	1	2	3	4	5	6	7
6. Each crewmember should monitor other crewmembers for signs of stress or fatigue, and should discuss the situation with the crewmember.	1	2	3	4	5	6	7
7. Good communications and crew coordination are as important as technical proficiency for the safety of the flight.	1	2	3	4	5	6	7
8. Crewmembers should be aware of and sensitive to the personal problems of other crewmembers.	1	2	3	4	5	6	7
9. The pilot-in-command, time and situation permitting, should take control and fly the aircraft in all emergency and non-standard situations.	1	2	3	4	5	6	7
10. The pilot flying the aircraft should verbalize plans for procedures or maneuvers and should be sure that the information is understood and acknowledged by crewmembers affected.	1	2	3	4	5	6	7
11. Pilots and other crewmembers should not question the decisions or actions of the pilot-in-command except when these actions obviously threaten the safety of the flight.	1	2	3	4	5	6	7
12. Even when fatigued, I perform effectively during most critical flight maneuvers.	1	2	3	4	5	6	7
13. Pilots-in-command should encourage pilots and crew chiefs to question procedures and flight profile deviations during normal flight operations and in emergencies.	1	2	3	4	5	6	7
14. There are no circumstances where the pilot should take the aircraft controls without being directed to do so by the pilot-in-command.	1	2	3	4	5	6	7

	Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree
15. A debriefing and critique of procedures and decisions after each mission is an important part of developing and maintaining effective crew coordination.	1	2	3	4	5	6	7
16. Training is one of the pilot-in-command's important responsibilities.	1	2	3	4	5	6	7
17. Under high stress, good crew coordination is <u>more</u> important than it is under low stress conditions.	1	2	3	4	5	6	7
18. Effective crew coordination requires crewmembers to take into account the personalities of other crewmembers.	1	2	3	4	5	6	7
19. The pilot-in-command's responsibilities include coordination of inflight crew chief activities.	1	2	3	4	5	6	7
20. Most crewmembers can leave personal problems behind when flying a mission.	1	2	3	4	5	6	7
21. My decision making ability is as good in emergencies as in routine mission situations.	1	2	3	4	5	6	7
22. Leadership of the crew team is solely the responsibility of the pilot-in-command.	1	2	3	4	5	6	7
23. Crew chief questions and suggestions should be considered by the pilots.	1	2	3	4	5	6	7
24. When joining a unit , a new crewmember should not offer suggestions or opinions unless asked.	1	2	3	4	5	6	7
25. The rank differences between officer and enlisted crewmembers can create barriers that threaten mission safety and effectiveness.	1	2	3	4	5	6	7
26. Because crew chiefs have no pilot training, they should limit their attention to their formally defined crewchief duties	1	2	3	4	5	6	7
27. Pilots-in-command who accept and implement suggestions from the crew are lessening their stature and reducing their authority.	1	2	3	4	5	6	7
28. Crewmembers should monitor the pilot-in-command's performance for possible mistakes and errors	1	2	3	4	5	6	7
29. Corrections to crew mistakes should be implemented directly by the pilot-in-command whenever physically possible.	1	2	3	4	5	6	7
30. The best way to correct an error is to alert the error maker so that he can correct the problem.	1	2	3	4	5	6	7

	Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree
31. Crewmember errors and mistakes during the mission, including the pilot-in-command's mistakes, should be a significant part of post flight crew discussions.	1	2	3	4	5	6	7
32. The pilot-in-command should seek advice from crewmembers in updating mission plans.	1	2	3	4	5	6	7
33. The pilot-in-command should use his crew to help him maintain situation awareness.	1	2	3	4	5	6	7
34. It is solely the responsibility of the pilot-in-command to maintain awareness of crew capabilities.	1	2	3	4	5	6	7
35. Only when the pilot-in-command is overloaded should he pass workload to other crewmembers.	1	2	3	4	5	6	7
36. Crewmembers should be aware of the workload placed on other crewmembers.	1	2	3	4	5	6	7
37. If a crewmember is having difficulties executing his responsibilities, other crewmembers should provide assistance.	1	2	3	4	5	6	7
38. Task overload does not occur for highly competent pilots.	1	2	3	4	5	6	7
39. A crewmember should offer task help to another crewmember only if he is sure the crewmember needs it.	1	2	3	4	5	6	7
40. A pilot-in-command should not get involved with the execution of responsibilities assigned to other crewmembers.	1	2	3	4	5	6	7
41. Task overloads of crewmembers usually occur because the overloaded crewmember is not very competent.	1	2	3	4	5	6	7
42. Pilots-in-command should employ the same style of management in all situations and with all crewmembers.	1	2	3	4	5	6	7
43. Pilot-in-command instructions to other crewmembers should be general and non-specific so that each individual can practice self-management and can develop individual skills.	1	2	3	4	5	6	7
44. A relaxed attitude is essential to maintaining a cooperative and harmonious cockpit.	1	2	3	4	5	6	7
45. Reprimands are more effective than discussions in eliminating a poor flying habit in a crewmember.	1	2	3	4	5	6	7

APPENDIX A.2

ACE Checklist

UH-60 Aircrew Coordination Evaluation (ACE) Checklist

Rev. 4

(To Be Completed By Evaluator Observing the Mission)

I. Flight, Crew, and Equipment Information

1. Date: ______________________
2. Reporting Time: ______________
3. Mission Total Flying Hours: ______________
4. Mission Completion Time: ______________
5. Mission Total Time: ____________________ *(Subtract item #2 from item #4)*
6. Type Equipment: Acft Simulator *(circle one)*
7. Type Mission: SVC MTF TRNG *(circle one)*
8. NVG Used: Y or N *(circle one)* % Illumination Predicted: _____ Estimated Actual: _____
9. Mission Purpose/Description (include a listing of ATM Tasks Performed when appropriate): ____________

____

____

____

10. Type Flight Plan: VFR IFR Composite *(circle one)*
11. Predicted Condition: VMC IMC *(circle one)*
12. Actual Condition: VMC IMC *(circle one)*
13. Crew Composition *(checkmark for each crewmember present)*

    PC _____ PI _____ CP _____ CC _____

14. Previous experience of individuals as crewmembers flying together regardless of previous seat position; for example, for a two person crew, one pair would be marked; for a three person crew, three pairs would be marked. *(Mark all pairings as appropriate.)*

	Position Pairing	Estimated # Missions	Estimated # Hours
a.	PC - PI	________	________
b.	PC - CP	________	________
c.	PC - CC	________	________
d.	PI - CP	________	________
e.	PI - CC	________	________
f.	CP - CC	________	________

15. Cross-Indexing Code (Explain to aircrew that responses will not be used to evaluate individual aviators. Results will not become a part of the aviator's record. However, an individual identifier is necessary since most aviators will be completing other forms to support the research project.)

		Social Security Number
a.	PC	________________
b.	PI	________________
c.	CP	________________
d.	CC	________________

16. Evaluator Name: ______________________

17. Qualification: IP___ SP___ IE___ ME___
(Check One)

II. Crew Communications and Coordination

(Circle the one number on each dimension which best describes the behavior of the crew during the mission. Consult the "Instructions for Making Ratings on the ACE Checklist Dimensions" before making ratings.)

CREW COORDINATION BEHAVIORS		Very Poor	Poor	Borderline/ Marginal	Fully Acceptable	Good	Very Good	Superior
1.	Thorough pre-flight mission plan developed	1	2	3	4	5	6	7
2.	Statements/directives clear, timely, relevant, complete, and verified	1	2	3	4	5	6	7
3.	Inquiry/questioning practiced	1	2	3	4	5	6	7
4.	Advocacy/assertion practiced	1	2	3	4	5	6	7
5.	Decisions communicated and acknowledged	1	2	3	4	5	6	7
6.	Actions communicated and acknowledged	1	2	3	4	5	6	7
7.	Crew self-critique of decisions and actions	1	2	3	4	5	6	7
8.	Crewmember actions mutually cross monitored	1	2	3	4	5	6	7
9.	Interpersonal relationships/group climate	1	2	3	4	5	6	7
10.	Aircraft , personnel, and mission status reported	1	2	3	4	5	6	7
11.	Distractions avoided or prioritized	1	2	3	4	5	6	7
12.	Workload effectively distributed/redistributed	1	2	3	4	5	6	7
13.	Support information/actions sought from crew	1	2	3	4	5	6	7
14.	Support information/actions offered by crew	1	2	3	4	5	6	7
OVERALL MISSION PERFORMANCE AND WORKLOAD		Very Low						Very High
15.	Overall technical proficiency	1	2	3	4	5	6	7
16.	Overall crew effectiveness	1	2	3	4	5	6	7
17.	Overall workload	1	2	3	4	5	6	7

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III. **Special Circumstances:** This section provides data on non-standard situations or behaviors that may influence crew performance. If abnormal emergency situations arose, rate the overall management of the situation. If conflicts occurred, rate how effectively they were resolved.

		Very Poor	Poor	Borderline/ Marginal	Fully Acceptable	Good	Very Good	Superior
18.	**Management of abnormal or emergency situation**	1	2	3	4	5	6	7
19.	**Conflict resolution**	1	2	3	4	5	6	7

20. **Individual Ratings: In some cases the actions of a <u>particular</u> crewmember may be particularly significant to the outcome of the mission. In cases where this happens, enter the relevant item number from the above items (1-14), check the position of the crewmember rated, and circle the appropriate number on the dimension which reflects that individual's performance.**

	Very Poor	Poor	Borderline/ Marginal	Fully Acceptable	Good	Very Good	Superior
______ Item ______ PC / ______ PI / ______ CP / ______ CC	1	2	3	4	5	6	7
______ Item ______ PC / ______ PI / ______ CP / ______ CC	1	2	3	4	5	6	7
______ Item ______ PC / ______ PI / ______ CP / ______ CC	1	2	3	4	5	6	7

IV. **Comment on any extreme or unusual (especially 1 or 7) ratings on any item in Section II or III.**

Item #	Comments
______	______________________________
______	______________________________
______	______________________________
______	______________________________
______	______________________________

V. **Comments on Extreme or Unusual Conditions or Behaviors:** Describe conditions, conflicts, or unusual individual behaviors which occurred during the mission.

____

____

____

____

____

VI. Supplementary Information: Conditions which significantly influenced the flight (include weather, ATC information, pre-existing mechanicals, etc.) Describe below.

____

____

____

____

____

VII. Post Flight Questions (Ask the following questions <u>of each crewmember</u> after completion of the flight. Record the responses below.)

1. Were you aware that this specific mission or scenario would be used prior to reporting to the flight line today? Response options are as follows:

   0 - <u>No Information</u> about any aspect of the mission or scenario

   1 - <u>Slight Familiarity</u> with the mission and/or scenario

   2 - <u>Considerable Familiarity</u> with the mission and/or scenario

   3 - <u>Detailed Information</u> on the mission and scenario

   (Circle one response for each participating crew member, (e.g., PC: 0))

	No Information	Slight Familiarity	Considerable Familiarity	Detailed Information
1. PC:	0	1	2	3
2. PI:	0	1	2	3
3. CP:	0	1	2	3
4. CC:	0	1	2	3

2. To what extent did you experience motion sickness during this simulator session/flight? (Circle one response for each participating crewmember.)

	None	Scarcely any	Very Little	A little	Some	Quite a bit	A great deal
1. PC:	0	1	2	3	4	5	6
2. PI:	0	1	2	3	4	5	6
3. CP:	0	1	2	3	4	5	6
4. CC:	0	1	2	3	4	5	6

APPENDIX A.3

Modified Gradeslips

* TESTBED EVALUATION GRADE SLIP	
AIRCREW	SSN, PIC:____________________ SSN, PI: ____________________
EVALUATOR	NAME: ____________________

TESTBED SIMULATOR FLIGHT DATA

TIME TODAY: _______

CUMULATIVE TIME:
PIC ________
PI ________
AS CREW ________

TYPE SIMULATOR: 2B38 (UH-60 FLIGHT SIMULATOR)

SCENARIO #: ________________

EVALUATOR DEBRIEFING STATEMENT/AIRCREW GRADE

I HAVE DEBRIEFED THE TESTBED AIRCREW AND ADVISED THEM OF THEIR GRADE.

YES: ___ NO: ___

OVERALL GRADE FOR THIS FLIGHT IS:

A	B	C	U	NA

TODAY'S DATE: ____________________

* GRADE SLIPS WILL NOT BE PART OF AVIATORS ATM FILE

MANEUVER/PROCEDURE GRADE SLIP FOR TESTBED AIRCREWS

AIRCREW	SSN, PIC ______________________	
	SSN, PI ______________________	
EVALUATOR	NAME: ______________________	
SCENARIO: ________	DATE: ______________________	

NO	MANEUVER/PROCEDURE	GR*	NO	MANEUVER/PROCEDURE	GR*
1001	VFR FLIGHT PLANNING		1028	VMC APPROACH	
1002	IFR FLIGHT PLANNING		1029	ROLL-ON LANDING	
1003	DD FORM 365-4		1031	CONFINED AREA OPERATIONS	
1004	DD FORM 5701-R		1032	SLOPE OPERATIONS	
1005	PREFLIGHT INSPECTION		1036	HOVER OGE CHECK	
1007	ENGINE START RUN-UP AND BEFORE TAKEOFF CHECKS		1053	SIMULATED ENGINE FAILURE AT ALTITUDE	
1015	GROUND TAXI		1057	SIMULATED HYDRAULIC SYSTEM MALFUNCTION	
1016	HOVER POWER CHECK		1058	DEGRADED AFCS	
1017	HOVERING FLIGHT		1062	ECU LOCKOUT OPERATIONS	
1018	NORMAL TAKEOFF		1063	STABILATOR MALFUNCTION PROCEDURES	
1019	ROLLING TAKEOFF		1068	EMERGENCY PROCEDURES	
1020	SIMULATED MAXIMUM PERFORMANCE TAKEOFF		1071	AIRCREW COORDINATION	
1021	DECELERATION/ACCELERATION		1075	INSTRUMENT TAKEOFF	
1022	TRAFFIC PATTERN FLIGHT		1076	RADIO NAVIGATION	
1023	FUEL MANAGEMENT PROCEDURES		1077	HOLDING PROCEDURES	
1025	PILOTAGE AND DEAD RECKONING		1078	UNUSAL ATTITUDE RECOVERY	
1026	DOPPLER NAVIGATION		1079	RADIO COMMUNICATIONS PROCEDURES	
1027	BEFORE-LANDING CHECK		1080	PROCEDURES FOR TWO-WAY RADIO FAILURE	

MANEUVER/PROCEDURE GRADE SLIP FOR TESTBED AIRCREWS (CONTINUED)

NO	MANEUVER/PROCEDURE	GR*
1081	NONPRECISION APPROACH	
1082	PRECISION APPROACH	
1083	VHIRP	
1084	COMMAND INSTRUMENT SYSTEM OPERATIONS	
1095	AIRCRAFT SURVIVABILITY EQUIPMENT	
1098	AFTER LANDING TASKS	
1099	MARK XII IFF SYSTEM	
2004	PINNACLE OR RIDGELINE OPERATION	
2005	FM RADIO HOMING	
2007	AERIAL OBSERVATION	
2008	EVASIVE MANEUVERS	
2009	MULTIAIRCRAFT OPERATIONS	
2010	RAPPELLING OPERATIONS	
2011	INTERNAL RESCUE-HOIST OPERATIONS	
2012	AERIAL MINE DELIVERY	
2016	PERFORM EXTERNAL LOAD OPERATIONS	
2081	PERFORM TERRAIN FLIGHT	
2084	PERFORM TERRAIN FLIGHT APPROACH	

* For highlighted tasks, top half of grade block is for maneuver/procedure grade. If grade is B, C, or U, enter if flight skill "f" or aircrew coordination "a" deficiency. For "a", note standard from Task 1071. (See example below)

2081	PERFORM TERRAIN FLIGHT	C
		a 1,3

TESTBED EVALUATION COMMENT SLIP	
AIRCREW	SSN, PIC ______________ SSN, PI ______________
EVALUATOR	NAME: ______________
SCENARIO: ______	DATE: ______________

COMMENTS

TESTBED EVALUATION COMMENT SLIP (cont)   PAGE _____

APPENDIX A.4

Experimental Ratings of Aviator Qualities

Experimental Rating of Aviator Qualities

The Army Research Institute (ARI) is researching the area of cockpit management in Army Aviation. The goal is to improve performance and increase the margin of safety on an Army-wide basis. Other DoD services and commercial aviation have also looked into the area of cockpit management and have realized substantial gains in performance and safety. Army Aviation is unique and much of what has been discovered in other service branches and the commercial world is not applicable to the Army.

Consequently, ARI's program, designed to meet the needs of the Army, is multifaceted. Simulations are being developed to stress crew-type tasks; it is envisioned that enhanced training will be developed; the US Army Safety Center is incorporating crew coordination errors into their investigation process; and revisions to the APARTS program are being planned.

One component of ARI's research program is the Army Aviation Crewmember Questionnaire that asks aviators about their attitudes towards cockpit management. Aviators in your unit are being administered the questionnaire. There is, however, some additional information that we require to supplement the questionnaire data. Your assistance in providing this additional information is essential to the success of the research program since results of this survey will be used to guide us into our next phase.

IMPORTANT

The information you provide in this questionnaire is off the record and will be used for research purposes only. It will be kept completely confidential. It will not be attributed to you personally, nor will it become a part of any records kept on aviators in your unit. The names on the questionnaire are there only for your convenience and will be removed from the questionnaire once it is obtained by us. The social security numbers on the questionnaire will be used only as a cross-index number within the research database.

Rating Directions

Use the attached sheets for your rating. Go to the sheet marked "Rating Form-Aviator Qualities" and start by filling out the names of aviators in your unit with whom you are familiar. Use continuation sheets if necessary. Choose only those aviators whose habits, style, skill level, etc. you are familiar with. You will need to get the aviators' social security number from their records or ask them directly.

Using a three level scale, you will rate the aviators in each one of the four categories (columns) marked Cockpit Resource Management, Flying Skills, Safety, and Mission Effectiveness. You will give a rating of 1 to an aviator in the top 25%, a rating of 2 to an aviator in the middle 50%, and a rating of 3 to an aviator in the bottom 25% of the group. Each individual aviator may be rated in the same percentile bracket or a different percentile bracket for each major area. The rating you give an aviator in one category has no bearing on how you rate the aviator in another category.

Constructing the Scale

You will use the same three level scale for each category. You will need to construct the scale yourself. Here's how. First, total the number of aviators on your sheet. Next, divide the total by four. The number resulting from the division (without the remainder) is the number of aviators you will give a 1 rating. It is also the number of aviators you will give a 3 rating. The rest of the aviators will be rated as a 2.

For example, say there are 14 aviators you are rating on your sheet. You divide 14 by 4, and the answer is 3 (disregard the remainder of 2). Therefore, you will give three aviators a rating of 1, eight aviators a rating of 2, and three aviators a rating of 3.

Steps:

Step 1: Total the number of aviators you will rate.
Step 2: Divide the total by 4.
Step 3: Use the quotient (without the remainder) as the number of 1 ratings and the number of 3 ratings you can allocate.
Step 4: The rest of the aviators are allocated a rating of 2

EXAMPLES

Example 1:

Step 1: There are 14 aviators with whom you are familiar.
Step 2: 14/4 = 3, remainder 2
Step 3: & 4 Allocation Allowance is: three 1 ratings
eight 2 ratings
three 3 ratings

Example 2:

Step 1: There are 17 aviators with whom you are familiar.
Step 2: 17/4 = 4, remainder 1
Step 3: & 4 Allocation Allowance is: four 1 ratings
nine 2 ratings
four 3 ratings

Once you know how many aviators you can place within each of the three levels, proceed to apply the ratings in the columns. The definitions to be used in considering each column are on the next page.

Applying the Ratings

Within each category (column) give the aviators a rating of 1, 2, or 3. Use exactly the number of 1's, 2's and 3's you are allowed within each category (column). Descriptions of the qualities named at the top of each column are given below. Each column is for a distinct quality. You'll need to read the descriptions carefully so you understand how each column requires a rating of a different quality.

The aviators on your list are probably of varying experience levels. Try to rate the aviators taking into account their experience levels. For example, a new aviator may not be one of your best cockpit resource managers, but considering his experience level he may be among the top 25% of aviators at his experience level. In that case, you should give him a rating of 1.

Cockpit Resource Management - The effective cockpit resource manager attempts to establish and maintain positive working and interpersonal relationships to create a harmonious team atmosphere and to execute mission objectives. He is sensitive to the capabilities of his fellow crewmembers, and, while he is a good leader, does not lead based on rank or crew position alone. He understands that errors are a fact of life and checks other's performance to detect errors. He manages workload well, and, in concert with the crew, effectively redistributes workload as the mission proceeds. He voluntarily helps out whenever he can. He maintains situation awareness and helps to prioritize crew tasks to ensure that the aircraft is being operated within acceptable parameters and that appropriate clearances are maintained. Finally, the effective cockpit manager is a good communicator; his communications are clear, timely, complete, relevant and transmitted using standard terminology. He seeks acknowledgement of his transmissions and, likewise, verifies receipt when others direct or provide information to him.

Flying Skills - This rating is an estimation of the aviator's flying proficiency - his "stick and rudder" skills. This aviator, regardless of his experience level, is in tune with the aircraft. While staying within acceptable parameters, he generally obtains optimal aircraft performance. He is a capable tactical aviator, understands what needs to be done in emergency or abnormal conditions, and knows how to handle the aircraft in even the most difficult situations.

Safety - This rating reflects the degree of safety awareness demonstrated by the aviator. A safe aviator, while willing to take risks, can assess risks in relation to mission objectives and individual capabilities. In accepting a particular level of risk, the aviator always balances the safety of the aircrew and the aircraft against accomplishing the mission. While the aviator may be strongly mission oriented, unacceptable risk is always rejected.

Mission Effectiveness- This rating is more global than the three mentioned above. It takes into account all three qualities and how the pilot combines them to accomplish assigned missions. The mission effective pilot "gets the job done." He knows how to manage cockpit resources, maintains safety awareness, and has highly regarded flying and navigation skills. He is the one to whom you would trust the most difficult assignments and missions since he has the right mix of intelligence, skills, attitudes, and courage to succeed.

Rating Form
Aviator Qualities

Date:_______

Evaluator Name:______________________________ Social Security #____________________

Qualification: IP_____ SP_____ IE _____ ME_____

Aviator Name	Aviator SSN	Ratings Cockpit Resource Managment	Flying Skills	Safety	Mission Effectiveness

(continue on next sheet)

Rating Form
Aviator Qualities

Date:_______

Evaluator Name:______________________________ Social Security #_____________________

Qualification: IP_____ SP_____ IE _____ ME_____

Aviator Name	Aviator SSN	Ratings: Cockpit Resource Managment	Flying Skills	Safety	Mission Effectiveness

(continue on next sheet)

Rating Form
Aviator Qualities

Date:_______

Evaluator Name:______________________________Social Security #____________________

Qualification: IP_____ SP_____ IE _____ ME_____

Aviator Name	Aviator SSN	Ratings Cockpit Resource Managment	Flying Skills	Safety	Mission Effectiveness

APPENDIX B

Army CMAQ Frequency Tables

APPENDIX B

CMAQ FREQUENCY TABLES

Table #1

C1 Crewmembers should avoid disagreeing with others because conflicts create tension and reduce crew effectiveness.

	Value	Frequency	Percent
Strongly Disagree	1	17	10.1
Disagree	2	64	38.1
Slightly Disagree	3	30	17.9
Neutral	4	9	5.4
Slightly Agree	5	20	11.9
Agree	6	25	14.9
Strongly Agree	7	3	1.8
		-------	-------
	TOTAL	168	100.0

Mean	3.226	Median	3.000	Std Dev	1.705
Valid Cases	168	Missing Cases	0		

Table #2

C2 Crewmembers should feel obligated to mention their own psychological stress or physical problems to other crewmembers before or during a mission.

	Value	Frequency	Percent
Disagree	2	6	3.6
Slightly Disagree	3	5	3.0
Neutral	4	10	6.0
Slightly Agree	5	28	16.7
Agree	6	76	45.2
Strongly Agree	7	43	25.6
		-------	-------
	TOTAL	168	100.0

Mean	5.738	Median	6.000	Std Dev	1.200
Valid Cases	168	Missing Cases	0		

Table #3

C3 It is important to comment about the procedures and techniques of other crewmembers.

	Value	Frequency	Percent
Disagree	2	4	2.4
Slightly Disagree	3	8	4.8
Neutral	4	10	6.0
Slightly Agree	5	37	22.0
Agree	6	90	53.6
Strongly Agree	7	19	11.3
		-------	-------
	TOTAL	168	100.0

Mean	5.536	Median	6.000	Std Dev	1.083
Valid Cases	168	Missing Cases	0		

Table #4

C4 Pilots-in-command should not dictate flight techniques to other crewmembers.

	Value	Frequency	Percent
Strongly Disagree	1	4	2.4
Disagree	2	24	14.3
Slightly Disagree	3	29	17.3
Neutral	4	13	7.7
Slightly Agree	5	39	23.2
Agree	6	49	29.2
Strongly Agree	7	10	6.0
		-------	-------
	TOTAL	168	100.0

Mean	4.464	Median	5.000	Std Dev	1.641
Valid Cases	168	Missing Cases	0		

Table #5

C5 Casual social conversation during periods of low workload can improve crew coordination.

	Value	Frequency	Percent
Disagree	2	3	1.8
Slightly Disagree	3	5	3.0
Neutral	4	24	14.3
Slightly Agree	5	32	19.0
Agree	6	78	46.4
Strongly Agree	7	26	15.5
	TOTAL	168	100.0

Mean	5.518	Median	6.000	Std Dev	1.116
Valid Cases	168	Missing Cases	0		

Table #6

C6 Each crewmember should monitor other crewmembers for signs of stress or fatigue, and should discuss the situation with the crewmember.

	Value	Frequency	Percent
Neutral	4	3	1.8
Slightly Agree	5	16	9.5
Agree	6	91	54.2
Strongly Agree	7	58	34.5
	TOTAL	168	100.0

Mean	6.214	Median	6.000	Std Dev	.685
Valid Cases	168	Missing Cases	0		

Table #7

C7 Good communications and crew coordination are as important as technical proficiency for the safety of the flight.

	Value	Frequency	Percent
Slightly Disagree	3	1	.6
Neutral	4	2	1.2
Slightly Agree	5	7	4.2
Agree	6	60	35.7
Strongly Agree	7	98	58.3
		-------	-------
	TOTAL	168	100.0

Mean	6.500	Median	7.000	Std Dev	.692
Valid Cases	168	Missing Cases	0		

Table #8

C8 Crewmembers should be aware of and sensitive to the personal problems of other crewmembers.

	Value	Frequency	Percent
Disagree	2	1	.6
Slightly Disagree	3	1	.6
Neutral	4	10	6.0
Slightly Agree	5	39	23.2
Agree	6	92	54.8
Strongly Agree	7	25	14.9
		-------	-------
	TOTAL	168	100.0

Mean	5.756	Median	6.000	Std Dev	.844
Valid Cases	168	Missing Cases	0		

Table #9

C9 The pilot-in-command, time and situation permitting, should take control and fly the aircraft in all emergency and non-standard situations.

	Value	Frequency	Percent
Strongly Disagree	1	15	8.9
Disagree	2	47	28.0
Slightly Disagree	3	26	15.5
Neutral	4	16	9.5
Slightly Agree	5	22	13.1
Agree	6	34	20.2
Strongly Agree	7	8	4.8
		-------	-------
	TOTAL	168	100.0

Mean	3.696	Median	3.000	Std Dev	1.837
Valid Cases	168	Missing Cases	0		

Table #10

C10 The pilot flying the aircraft should verbalize plans for procedures or maneuvers and should be sure the information is understood and acknowledged by crewmembers affected.

	Value	Frequency	Percent
Slightly Disagree	3	1	.6
Neutral	4	3	1.8
Slightly Agree	5	20	11.9
Agree	6	97	57.7
Strongly Agree	7	47	28.0
		-------	-------
	TOTAL	168	100.0

Mean	6.107	Median	6.000	Std Dev	.718
Valid Cases	168	Missing Cases	0		

Table #11

C11 Pilots and other crewmembers should not question the decisions or actions of the pilot-in-command except when these actions obviously threaten the safety of the flight.

	Value	Frequency	Percent
Strongly Disagree	1	14	8.3
Disagree	2	67	39.9
Slightly Disagree	3	34	20.2
Neutral	4	9	5.4
Slightly Agree	5	22	13.1
Agree	6	18	10.7
Strongly Agree	7	4	2.4
	TOTAL	168	100.0

Mean	3.167	Median	3.000	Std Dev	1.626
Valid Cases	168	Missing Cases	0		

Table #12

C12 Even when fatigued, I perform effectively during most critical flight maneuvers.

	Value	Frequency	Percent
Strongly Disagree	1	15	8.9
Disagree	2	50	29.8
Slightly Disagree	3	32	19.0
Neutral	4	21	12.5
Slightly Agree	5	28	16.7
Agree	6	20	11.9
Strongly Agree	7	2	1.2
	TOTAL	168	100.0

Mean	3.387	Median	3.000	Std Dev	1.604
Valid Cases	168	Missing Cases	0		

Table #13

C13 Pilots-in-command should encourage pilots and crew chiefs to question procedures and flight profile deviations during normal flight operations and in emergencies.

	Value	Frequency	Percent
Strongly Disagree	1	1	.6
Disagree	2	9	5.4
Slightly Disagree	3	7	4.2
Neutral	4	6	3.6
Slightly Agree	5	44	26.2
Agree	6	77	45.8
Strongly Agree	7	24	14.3
		-------	-------
	TOTAL	168	100.0

Mean	5.440	Median	6.000	Std Dev	1.275
Valid Cases	168	Missing Cases	0		

Table #14

C14 There are no circumstances where the pilot should take the aircraft controls without being directed to do so by the pilot-in-command.

	Value	Frequency	Percent
Strongly Disagree	1	43	25.6
Disagree	2	77	45.8
Slightly Disagree	3	25	14.9
Neutral	4	7	4.2
Slightly Agree	5	3	1.8
Agree	6	12	7.1
Strongly Agree	7	1	.6
		-------	-------
	TOTAL	168	100.0

Mean	2.345	Median	2.000	Std Dev	1.384
Valid Cases	168	Missing Cases	0		

Table #15

C15 A debriefing and critique of procedures and decisions after each mission is an important part of developing and maintaining effective crew coordination.

	Value	Frequency	Percent
Neutral	4	3	1.8
Slightly Agree	5	12	7.1
Agree	6	79	47.0
Strongly Agree	7	74	44.0
	TOTAL	168	100.0

Mean	6.333	Median	6.000	Std Dev	.689
Valid Cases	168	Missing Cases	0		

Table #16

C16 Training is one of the pilot-in-command's important responsibilities.

	Value	Frequency	Percent
Strongly Disagree	1	1	.6
Disagree	2	1	.6
Slightly Disagree	3	3	1.8
Neutral	4	5	3.0
Slightly Agree	5	13	7.7
Agree	6	84	50.0
Strongly Agree	7	61	36.3
	TOTAL	168	100.0

Mean	6.119	Median	6.000	Std Dev	.978
Valid Cases	168	Missing Cases	0		

Table #17

C17 Under high stress, good crew coordination is more important than it is under low stress conditions.

	Value	Frequency	Percent
Strongly Disagree	1	6	3.6
Disagree	2	13	7.7
Slightly Disagree	3	12	7.1
Neutral	4	4	2.4
Slightly Agree	5	17	10.1
Agree	6	65	38.7
Strongly Agree	7	51	30.4
		-------	-------
	TOTAL	168	100.0

Mean	5.452	Median	6.000	Std Dev	1.730
Valid Cases	168	Missing Cases	0		

Table #18

C18 Effective crew coordination requires crewmembers to take into account the personalities of other crewmembers.

	Value	Frequency	Percent
Strongly Disagree	1	1	.6
Disagree	2	3	1.8
Slightly Disagree	3	2	1.2
Neutral	4	9	5.4
Slightly Agree	5	37	22.0
Agree	6	83	49.4
Strongly Agree	7	33	19.6
		-------	-------
	TOTAL	168	100.0

Mean	5.732	Median	6.000	Std Dev	1.052
Valid Cases	168	Missing Cases	0		

Table #19

C19 The pilot-in-command's responsibilities include coordination of inflight crew chief activities.

	Value	Frequency	Percent
Neutral	4	3	1.8
Slightly Agree	5	14	8.3
Agree	6	104	61.9
Strongly Agree	7	47	28.0
	TOTAL	168	100.0

Mean	6.161	Median	6.000	Std Dev	.641
Valid Cases	168	Missing Cases	0		

Table #20

C20 Most crewmembers can leave personal problems behind when flying a mission.

	Value	Frequency	Percent
Strongly Disagree	1	12	7.1
Disagree	2	42	25.0
Slightly Disagree	3	34	20.2
Neutral	4	23	13.7
Slightly Agree	5	30	17.9
Agree	6	25	14.9
Strongly Agree	7	2	1.2
	TOTAL	168	100.0

Mean	3.595	Median	3.000	Std Dev	1.606
Valid Cases	168	Missing Cases	0		

Table #21

C21 My decision making ability is as good in emergencies as in routine mission situations.

	Value	Frequency	Percent
Strongly Disagree	1	5	3.0
Disagree	2	15	8.9
Slightly Disagree	3	31	18.5
Neutral	4	22	13.1
Slightly Agree	5	30	17.9
Agree	6	58	34.5
Strongly Agree	7	7	4.2
	TOTAL	168	100.0

Mean	4.542	Median	5.000	Std Dev	1.570
Valid Cases	168	Missing Cases	0		

Table #22

C22 Leadership of the crew team is solely the responsibility of the pilot-in-command.

	Value	Frequency	Percent
Strongly Disagree	1	13	7.7
Disagree	2	47	28.0
Slightly Disagree	3	27	16.1
Neutral	4	15	8.9
Slightly Agree	5	28	16.7
Agree	6	21	12.5
Strongly Agree	7	17	10.1
	TOTAL	168	100.0

Mean	3.768	Median	3.000	Std Dev	1.876
Valid Cases	168	Missing Cases	0		

Table #23

C23 Crew chief questions and suggestions should be considered by the pilots.

	Value	Frequency	Percent
Strongly Disagree	1	1	.6
Disagree	2	1	.6
Slightly Agree	5	12	7.1
Agree	6	87	51.8
Strongly Agree	7	67	39.9
	TOTAL	168	100.0

Mean	6.274	Median	6.000	Std Dev	.802
Valid Cases	168	Missing Cases	0		

Table #24

C24 When joining a unit, a new crewmember should not offer suggestions or opinions unless asked.

	Value	Frequency	Percent
Strongly Disagree	1	48	28.6
Disagree	2	84	50.0
Slightly Disagree	3	23	13.7
Neutral	4	7	4.2
Slightly Agree	5	3	1.8
Agree	6	2	1.2
Strongly Agree	7	1	.6
	TOTAL	168	100.0

Mean	2.065	Median	2.000	Std Dev	1.045
Valid Cases	168	Missing Cases	0		

Table #25

C25 The rank differences between officer and enlisted crewmembers can create barriers that threaten mission safety and effectiveness.

	Value	Frequency	Percent
Strongly Disagree	1	18	10.7
Disagree	2	49	29.2
Slightly Disagree	3	21	12.5
Neutral	4	11	6.5
Slightly Agree	5	33	19.6
Agree	6	32	19.0
Strongly Agree	7	4	2.4
	TOTAL	168	100.0

Mean	3.619	Median	3.000	Std Dev	1.817
Valid Cases	168	Missing Cases	0		

Table #26

C26 Because crew chiefs have no pilot training, they should limit their attention to their formally defined crewchief duties.

	Value	Frequency	Percent
Strongly Disagree	1	32	19.0
Disagree	2	69	41.1
Slightly Disagree	3	42	25.0
Neutral	4	12	7.1
Slightly Agree	5	6	3.6
Agree	6	4	2.4
Strongly Agree	7	3	1.8
	TOTAL	168	100.0

Mean	2.494	Median	2.000	Std Dev	1.281
Valid Cases	168	Missing Cases	0		

Table #27

C27 Pilots-in-command who accept and implement suggestions from the crew are lessening their stature and reducing their authority.

	Value	Frequency	Percent
Strongly Disagree	1	76	45.2
Disagree	2	74	44.0
Slightly Disagree	3	13	7.7
Neutral	4	3	1.8
Slightly Agree	5	1	.6
Agree	6	1	.6
	TOTAL	168	100.0

Mean	1.702	Median	2.000	Std Dev	.816
Valid Cases	168	Missing Cases	0		

Table #28

C28 Crewmembers should monitor the pilot-in-command's performance for possible mistakes and errors.

	Value	Frequency	Percent
Strongly Disagree	1	3	1.8
Disagree	2	10	6.0
Slightly Disagree	3	9	5.4
Neutral	4	15	8.9
Slightly Agree	5	33	19.6
Agree	6	74	44.0
Strongly Agree	7	24	14.3
	TOTAL	168	100.0

Mean	5.280	Median	6.000	Std Dev	1.439
Valid Cases	168	Missing Cases	0		

Table #29

C29 Corrections to crew mistakes should be implemented directly by the pilot-in-command whenever physically possible.

	Value	Frequency	Percent
Strongly Disagree	1	1	.6
Disagree	2	24	14.3
Slightly Disagree	3	15	8.9
Neutral	4	31	18.5
Slightly Agree	5	36	21.4
Agree	6	58	34.5
Strongly Agree	7	3	1.8
	TOTAL	168	100.0

Mean	4.565	Median	5.000	Std Dev	1.471
Valid Cases	168	Missing Cases	0		

Table #30

C30 The best way to correct an error is to alert the error maker so that he can correct the problem.

	Value	Frequency	Percent
Disagree	2	4	2.4
Neutral	4	5	3.0
Slightly Agree	5	32	19.0
Agree	6	95	56.5
Strongly Agree	7	32	19.0
	TOTAL	168	100.0

Mean	5.845	Median	6.000	Std Dev	.929
Valid Cases	168	Missing Cases	0		

Table #31

C31 Crewmember errors and mistakes during the mission, including the pilot-in-command's mistakes, should be a significant part of post flight crew discussions.

	Value	Frequency	Percent
Disagree	2	1	.6
Slightly Disagree	3	3	1.8
Neutral	4	1	.6
Slightly Agree	5	20	11.9
Agree	6	90	53.6
Strongly Agree	7	53	31.5
	TOTAL	168	100.0

Mean	6.107	Median	6.000	Std Dev	.841
Valid Cases	168	Missing Cases	0		

Table #32

C32 The pilot-in-command should seek advice from crewmembers in updating mission plans.

	Value	Frequency	Percent
Disagree	2	1	.6
Slightly Disagree	3	2	1.2
Neutral	4	3	1.8
Slightly Agree	5	33	19.6
Agree	6	94	56.0
Strongly Agree	7	35	20.8
	TOTAL	168	100.0

Mean	5.917	Median	6.000	Std Dev	.822
Valid Cases	168	Missing Cases	0		

Table #33

C33 The pilot-in-command should use his crew to help him maintain situation awareness.

	Value	Frequency	Percent
Slightly Agree	5	6	3.6
Agree	6	74	44.0
Strongly Agree	7	88	52.4
	TOTAL	168	100.0

Mean	6.488	Median	7.000	Std Dev	.569
Valid Cases	168	Missing Cases	0		

Table #34

C34 It is solely the responsibility of the pilot-in-command to maintain awareness of crew capabilities.

	Value	Frequency	Percent
Strongly Disagree	1	27	16.1
Disagree	2	68	40.5
Slightly Disagree	3	27	16.1
Neutral	4	13	7.7
Slightly Agree	5	11	6.5
Agree	6	18	10.7
Strongly Agree	7	3	1.8
	.	1	.6
	TOTAL	168	100.0

Mean	2.874	Median	2.000	Std Dev	1.629
Valid Cases	167	Missing Cases	1		

Table #35

C35 Only when the pilot-in-command is overloaded should he pass workload to other crewmembers.

	Value	Frequency	Percent
Strongly Disagree	1	56	33.3
Disagree	2	88	52.4
Slightly Disagree	3	15	8.9
Neutral	4	3	1.8
Slightly Agree	5	2	1.2
Agree	6	3	1.8
Strongly Agree	7	1	.6
	TOTAL	168	100.0

Mean	1.929	Median	2.000	Std Dev	1.018
Valid Cases	168	Missing Cases	0		

Table #36

C36 Crewmembers should be aware of the workload placed on other crewmembers.

	Value	Frequency	Percent
Neutral	4	1	.6
Slightly Agree	5	13	7.7
Agree	6	115	68.5
Strongly Agree	7	39	23.2
	TOTAL	168	100.0

Mean	6.143	Median	6.000	Std Dev	.561
Valid Cases	168	Missing Cases	0		

Table #37

C37 If a crewmember is having difficulties executing his responsibilities, other crewmembers should provide assistance.

	Value	Frequency	Percent
Disagree	2	1	.6
Slightly Agree	5	11	6.5
Agree	6	105	62.5
Strongly Agree	7	51	30.4
	TOTAL	168	100.0

Mean	6.214	Median	6.000	Std Dev	.649
Valid Cases	168	Missing Cases	0		

Table #38

C38 Task overload does not occur for highly competent pilots.

	Value	Frequency	Percent
Strongly Disagree	1	70	41.7
Disagree	2	78	46.4
Slightly Disagree	3	12	7.1
Neutral	4	3	1.8
Slightly Agree	5	1	.6
Agree	6	3	1.8
Strongly Agree	7	1	.6
	TOTAL	168	100.0

Mean	1.810	Median	2.000	Std Dev	1.009
Valid Cases	168	Missing Cases	0		

Table #39

C39 A crewmember should offer task help to another crewmember only if he is sure the crewmember needs it.

	Value	Frequency	Percent
Strongly Disagree	1	17	10.1
Disagree	2	67	39.9
Slightly Disagree	3	54	32.1
Neutral	4	13	7.7
Slightly Agree	5	9	5.4
Agree	6	8	4.8
	TOTAL	168	100.0

Mean	2.726	Median	2.500	Std Dev	1.207
Valid Cases	168	Missing Cases	0		

Table #40

C40 A pilot-in-command should not get involved with the execution of responsibilities assigned to other crewmembers.

	Value	Frequency	Percent
Strongly Disagree	1	21	12.5
Disagree	2	86	51.2
Slightly Disagree	3	36	21.4
Neutral	4	9	5.4
Slightly Agree	5	11	6.5
Agree	6	2	1.2
Strongly Agree	7	3	1.8
	TOTAL	168	100.0

Mean	2.530	Median	2.000	Std Dev	1.228
Valid Cases	168	Missing Cases	0		

Table #41

C41 Task overloads of crewmembers usually occur because the overloaded crewmember is not very competent.

	Value	Frequency	Percent
Strongly Disagree	1	33	19.6
Disagree	2	89	53.0
Slightly Disagree	3	27	16.1
Neutral	4	5	3.0
Slightly Agree	5	13	7.7
Strongly Agree	7	1	.6
	TOTAL	168	100.0

Mean	2.286	Median	2.000	Std Dev	1.117
Valid Cases	168	Missing Cases	0		

Table #42

C42 Pilots-in-command should employ the same style of management in all situations and with all crewmembers.

	Value	Frequency	Percent
Strongly Disagree	1	34	20.2
Disagree	2	65	38.7
Slightly Disagree	3	32	19.0
Neutral	4	8	4.8
Slightly Agree	5	12	7.1
Agree	6	14	8.3
Strongly Agree	7	3	1.8
	TOTAL	168	100.0

Mean	2.720	Median	2.000	Std Dev	1.582
Valid Cases	168	Missing Cases	0		

Table #43

C43 Pilot-in-command instructions to other crewmembers should be general and non-specific so that each individual can practice self-management and can develop individual skills.

	Value	Frequency	Percent
Strongly Disagree	1	23	13.7
Disagree	2	67	39.9
Slightly Disagree	3	34	20.2
Neutral	4	17	10.1
Slightly Agree	5	16	9.5
Agree	6	8	4.8
Strongly Agree	7	3	1.8
	TOTAL	168	100.0

Mean	2.833	Median	2.000	Std Dev	1.459
Valid Cases	168	Missing Cases	0		

Table #44

C44 A relaxed attitude is essential to maintaining a cooperative and harmonious cockpit.

	Value	Frequency	Percent
Disagree	2	6	3.6
Slightly Disagree	3	18	10.7
Neutral	4	12	7.1
Slightly Agree	5	42	25.0
Agree	6	66	39.3
Strongly Agree	7	24	14.3
	TOTAL	168	100.0

Mean	5.286	Median	6.000	Std Dev	1.309
Valid Cases	168	Missing Cases	0		

Table #45

C45 Reprimands are more effective than discussions in eliminating a poor flying habit in a crewmember.

	Value	Frequency	Percent
Strongly Disagree	1	59	35.1
Disagree	2	78	46.4
Slightly Disagree	3	18	10.7
Neutral	4	9	5.4
Slightly Agree	5	2	1.2
Agree	6	2	1.2
	TOTAL	168	100.0

Mean	1.946	Median	2.000	Std Dev	.986
Valid Cases	168	Missing Cases	0		

APPENDIX C

ACE Checklist Frequency Tables

APPENDIX C

ACE CHECKLIST FREQUENCY TABLES

Table #1

A1 Thorough pre-flight mission plan developed

	Value	Frequency	Percent
Very Poor	1	1	5.0
Poor	2	3	15.0
Borderline/Marginal	3	3	15.0
Fully Acceptable	4	5	25.0
Good	5	5	25.0
Very Good	6	2	10.0
Superior	7	1	5.0
	TOTAL	20	100.0

Mean	4.000	Std Err	.348	Std Dev	1.556
Valid Cases	20	Missing Cases	0		

Table #2

A2 Statements/directives clear, timely, relevant

	Value	Frequency	Percent
Very Poor	1	2	10.0
Poor	2	5	25.0
Borderline/Marginal	3	7	35.0
Fully Acceptable	4	5	25.0
Good	5	1	5.0
	TOTAL	20	100.0

Mean	2.900	Std Err	.240	Std Dev	1.071
Valid Cases	20	Missing Cases	0		

Table #3

A3 Inquiry/questioning practiced

	Value	Frequency	Percent
Poor	2	7	35.0
Borderline/Marginal	3	5	25.0
Fully Acceptable	4	6	30.0
Good	5	2	10.0
	TOTAL	20	100.0

Mean	3.150	Std Err	.233	Std Dev	1.040
Valid Cases	20	Missing Cases	0		

Table #4

A4 Advocacy/assertion practiced

	Value	Frequency	Percent
Very Poor	1	1	5.0
Poor	2	4	20.0
Borderline/Marginal	3	8	40.0
Fully Acceptable	4	6	30.0
Good	5	1	5.0
	TOTAL	20	100.0

Mean	3.100	Std Err	.216	Std Dev	.968
Valid Cases	20	Missing Cases	0		

Table #5

A5 Decisions communicated and acknowledged

	Value	Frequency	Percent
Poor	2	5	25.0
Borderline/Marginal	3	8	40.0
Fully Acceptable	4	6	30.0
Good	5	1	5.0
	TOTAL	20	100.0

Mean	3.150	Std Err	.196	Std Dev	.875
Valid Cases	20	Missing Cases	0		

Table #6

A6 Actions communicated and acknowledged

	Value	Frequency	Percent
Poor	2	4	20.0
Borderline/Marginal	3	9	45.0
Fully Acceptable	4	6	30.0
Good	5	1	5.0
	TOTAL	20	100.0

Mean	3.200	Std Err	.186	Std Dev	.834
Valid Cases	20	Missing Cases	0		

Table #7

A7 Crew self-critique of decisions and actions

	Value	Frequency	Percent
Very Poor	1	1	5.0
Poor	2	1	5.0
Borderline/Marginal	3	7	35.0
Fully Acceptable	4	10	50.0
Very Good	6	1	5.0
	TOTAL	20	100.0

Mean	3.500	Std Err	.224	Std Dev	1.000
Valid Cases	20	Missing Cases	0		

Table #8

A8 Crewmember actions mutually cross monitored

	Value	Frequency	Percent
Very Poor	1	1	5.0
Poor	2	8	40.0
Borderline/Marginal	3	2	10.0
Fully Acceptable	4	8	40.0
Very Good	6	1	5.0
	TOTAL	20	100.0

Mean	3.050	Std Err	.276	Std Dev	1.234
Valid Cases	20	Missing Cases	0		

Table #9

A9 Interpersonal relationships/group climate

	Value	Frequency	Percent
Borderline/Marginal	3	3	15.0
Fully Acceptable	4	16	80.0
Very Good	6	1	5.0
	TOTAL	20	100.0

Mean	3.950	Std Err	.135	Std Dev	.605
Valid Cases	20	Missing Cases	0		

Table #10

A10 Aircraft, personnel, and mission status

	Value	Frequency	Percent
Poor	2	3	15.0
Borderline/Marginal	3	8	40.0
Fully Acceptable	4	7	35.0
Good	5	2	10.0
	TOTAL	20	100.0

Mean	3.400	Std Err	.197	Std Dev	.883
Valid Cases	20	Missing Cases	0		

Table #11

A11 Distractions avoided or prioritized

	Value	Frequency	Percent
Very Poor	1	1	5.0
Poor	2	2	10.0
Borderline/Marginal	3	10	50.0
Fully Acceptable	4	6	30.0
Good	5	1	5.0
	TOTAL	20	100.0

Mean	3.200	Std Err	.200	Std Dev	.894
Valid Cases	20	Missing Cases	0		

Table #12

A12 Workload effectively distributed/redistributed

	Value	Frequency	Percent
Very Poor	1	1	5.0
Poor	2	1	5.0
Borderline/Marginal	3	5	25.0
Fully Acceptable	4	12	60.0
Good	5	1	5.0
	TOTAL	20	100.0

Mean	3.550	Std Err	.198	Std Dev	.887
Valid Cases	20	Missing Cases	0		

Table #13

A13 Support information/actions sought from crew

	Value	Frequency	Percent
Very Poor	1	2	10.0
Poor	2	3	15.0
Borderline/Marginal	3	6	30.0
Fully Acceptable	4	7	35.0
Good	5	2	10.0
	TOTAL	20	100.0

Mean	3.200	Std Err	.258	Std Dev	1.152
Valid Cases	20	Missing Cases	0		

Table #14

A14 Support information/actions offered by crew

	Value	Frequency	Percent
Very Poor	1	2	10.0
Poor	2	5	25.0
Borderline/Marginal	3	5	25.0
Fully Acceptable	4	5	25.0
Good	5	3	15.0
	TOTAL	20	100.0

Mean	3.100	Std Err	.280	Std Dev	1.252
Valid Cases	20	Missing Cases	0		

Table #15

A15 Overall technical proficiency

	Value	Frequency	Percent
Very Low	1	1	5.0
	2	2	10.0
	3	9	45.0
	4	7	35.0
Very High	5	1	5.0
	TOTAL	20	100.0

Mean	3.250	Std Err	.204	Std Dev	.910
Valid Cases	20	Missing Cases	0		

Table #16

A16 Overall crew effectiveness

	Value	Frequency	Percent
Very Low	1	2	10.0
	2	1	5.0
	3	9	45.0
	4	5	25.0
Very High	5	3	15.0
	TOTAL	20	100.0

Mean	3.300	Std Err	.252	Std Dev	1.129
Valid Cases	20	Missing Cases	0		

Table #17

A17 Overall workload

	Value	Frequency	Percent
Very Low	1	1	5.0
	2	1	5.0
	3	1	5.0
	4	15	75.0
Very High	5	2	10.0
	TOTAL	20	100.0

Mean	3.800	Std Err	.200	Std Dev	.894
Valid Cases	20	Missing Cases	0		

Table #18

A18 Management of abnormal or emergency situations

	Value	Frequency	Percent
Very Poor	1	1	5.0
Poor	2	5	25.0
Borderline/Marginal	3	7	35.0
Fully Acceptable	4	6	30.0
Good	5	1	5.0
	TOTAL	20	100.0

Mean	3.050	Std Err	.223	Std Dev	.999
Valid Cases	20	Missing Cases	0		

Table #19

A19 Conflict resolution

	Value	Frequency	Percent
Poor	2	5	25.0
Borderline/Marginal	3	6	30.0
Fully Acceptable	4	7	35.0
Good	5	1	5.0
Very Good	6	1	5.0
	TOTAL	20	100.0

Mean	3.350	Std Err	.244	Std Dev	1.089
Valid Cases	20	Missing Cases	0		

APPENDIX D

Revised ATM Tasks, Modified Gradeslips
Frequency Tables

APPENDIX D

ATM FREQUENCY TABLES

Table #1

BIGRADE   Overall grade for flight

Value	Frequency	Percent
1	4	20.0
2	8	40.0
3	8	40.0
TOTAL	20	100.0

Mean	2.200	Median	2.000	Std Dev	.768
Valid Cases	20	Missing Cases	0		

Table #2

T1001   Task 1001   VFR Flight Planning

	Value	Frequency	Percent
U	1	3	15.0
C	2	3	15.0
B	3	7	35.0
A	4	7	35.0
	TOTAL	20	100.0

Mean	2.900	Median	3.000	Std Dev	1.071
Valid Cases	20	Missing Cases	0		

Table #3

T1003 Task 1003 DD Form 365-4

	Value	Frequency	Percent
U	1	3	15.0
C	2	3	15.0
B	3	7	35.0
A	4	7	35.0
	TOTAL	20	100.0

Mean	2.900	Median	3.000	Std Dev	1.071
Valid Cases	20	Missing Cases	0		

Table #4

T1004 Task 1004 DD Form 5701-R

	Value	Frequency	Percent
U	1	1	5.0
C	2	7	35.0
B	3	2	10.0
A	4	2	10.0
	.	8	40.0
	TOTAL	20	100.0

Mean	2.417	Median	2.000	Std Dev	.900
Valid Cases	12	Missing Cases	8		

Table #5

T1007 Task 1007 Engine Start, Runup and Before Takeoff Checks

	Value	Frequency	Percent
U	1	5	25.0
C	2	3	15.0
B	3	10	50.0
A	4	2	10.0
	TOTAL	20	100.0

Mean	2.450	Median	3.000	Std Dev	.999
Valid Cases	20	Missing Cases	0		

Table #6

T1015 Task 1015 Ground Taxi

	Value	Frequency	Percent
B	3	1	5.0
	.	19	95.0
	TOTAL	20	100.0

Mean	3.000	Median	3.000
Valid Cases	1	Missing Cases	19

Table #7

T1016 Task 1016 Hover Power Check

	Value	Frequency	Percent
U	1	10	50.0
C	2	4	20.0
B	3	4	20.0
A	4	2	10.0
	TOTAL	20	100.0

Mean	1.900	Median	1.500	Std Dev	1.071
Valid Cases	20	Missing Cases	0		

Table #8

T1017 Task 1017 Hovering Flight

	Value	Frequency	Percent
C	2	4	20.0
B	3	16	80.0
	TOTAL	20	100.0

Mean	2.800	Median	3.000	Std Dev	.410
Valid Cases	20	Missing Cases	0		

Table #9

T1018 Task 1018 Normal Takeoff

	Value	Frequency	Percent
B	3	1	5.0
	.	19	95.0
	TOTAL	20	100.0

Mean 3.000 Median 3.000
Valid Cases 1 Missing Cases 19

Table #10

T1023 Task 1023 Fuel Management Procedures

	Value	Frequency	Percent
U	1	15	75.0
C	2	1	5.0
B	3	2	10.0
A	4	1	5.0
	.	1	5.0
	TOTAL	20	100.0

Mean 1.421 Median 1.000 Std Dev .902
Valid Cases 19 Missing Cases 1

Table #11

T1026 Task 1026 Doppler Navigation

	Value	Frequency	Percent
U	1	3	15.0
C	2	5	25.0
B	3	9	45.0
A	4	3	15.0
	TOTAL	20	100.0

Mean 2.600 Median 3.000 Std Dev .940
Valid Cases 20 Missing Cases 0

Table #12

T1027 Task 1027 Before Landing Check

	Value	Frequency	Percent
U	1	9	45.0
C	2	6	30.0
B	3	5	25.0
		-------	-------
	TOTAL	20	100.0

Mean	1.800	Median	2.000	Std Dev	.834
Valid Cases	20	Missing Cases	0		

Table #13

T1028 Task 1028 VMC Approach

	Value	Frequency	Percent
C	2	1	5.0
B	3	2	10.0
	.	17	85.0
		-------	-------
	TOTAL	20	100.0

Mean	2.667	Median	3.000	Std Dev	.577
Valid Cases	3	Missing Cases	17		

Table #14

T1031 Task 1031 Confined Area Operations

	Value	Frequency	Percent
C	2	6	30.0
B	3	14	70.0
		-------	-------
	TOTAL	20	100.0

Mean	2.700	Median	3.000	Std Dev	.470
Valid Cases	20	Missing Cases	0		

Table #15

T1036 Task 1036 Hover OGE Check

	Value	Frequency	Percent
U	1	1	5.0
C	2	1	5.0
B	3	2	10.0
	.	16	80.0
	TOTAL	20	100.0

Mean	2.250	Median	2.500	Std Dev	.957
Valid Cases	4	Missing Cases	16		

Table #16

T1063 Task 1063 Stabilator Malfunction Procedures

	Value	Frequency	Percent
U	1	8	40.0
C	2	6	30.0
B	3	6	30.0
	TOTAL	20	100.0

Mean	1.900	Median	2.000	Std Dev	.852
Valid Cases	20	Missing Cases	0		

Table #17

T1068 Task 1068 Emergency Procedures

	Value	Frequency	Percent
U	1	8	40.0
C	2	5	25.0
B	3	7	35.0
	TOTAL	20	100.0

Mean	1.950	Median	2.000	Std Dev	.887
Valid Cases	20	Missing Cases	0		

Table #18

T1071 Task 1071 Aircrew Coordination

	Value	Frequency	Percent
U	1	6	30.0
C	2	5	25.0
B	3	8	40.0
A	4	1	5.0
	TOTAL	20	100.0

Mean	2.200	Median	2.000	Std Dev	.951
Valid Cases	20	Missing Cases	0		

Table #19

T1076 Task 1076 Radio Navigation

	Value	Frequency	Percent
C	2	3	15.0
B	3	12	60.0
	.	5	25.0
	TOTAL	20	100.0

Mean	2.800	Median	3.000	Std Dev	.414
Valid Cases	15	Missing Cases	5		

Table #20

T1079 Task 1079 Radio Communication Procedures

	Value	Frequency	Percent
C	2	5	25.0
B	3	15	75.0
	TOTAL	20	100.0

Mean	2.750	Median	3.000	Std Dev	.444
Valid Cases	20	Missing Cases	0		

Table #21

T1081 Task 1081 Nonprecision Approach

	Value	Frequency	Percent
U	1	4	20.0
C	2	3	15.0
B	3	10	50.0
A	4	1	5.0
	.	2	10.0
	TOTAL	20	100.0

Mean	2.444	Median	3.000	Std Dev	.922
Valid Cases	18	Missing Cases	2		

Table #22

T1083 Task 1083 VHIRP

	Value	Frequency	Percent
U	1	2	10.0
C	2	7	35.0
B	3	4	20.0
A	4	5	25.0
	.	2	10.0
	TOTAL	20	100.0

Mean	2.667	Median	2.500	Std Dev	1.029
Valid Cases	18	Missing Cases	2		

Table #23

T1095 Task 1095 Aircraft Survivability Equipment

	Value	Frequency	Percent
U	1	8	40.0
C	2	3	15.0
B	3	9	45.0
	TOTAL	20	100.0

Mean	2.050	Median	2.000	Std Dev	.945
Valid Cases	20	Missing Cases	0		

Table #24

T1098 Task 1098 After Landing Tasks

	Value	Frequency	Percent
U	1	6	30.0
C	2	2	10.0
B	3	3	15.0
	.	9	45.0
	TOTAL	20	100.0

Mean	1.727	Median	1.000	Std Dev	.905
Valid Cases	11	Missing Cases	9		

Table #25

T1099 Task 1099 Mark XII IFF System

	Value	Frequency	Percent
U	1	8	40.0
C	2	1	5.0
B	3	8	40.0
A	4	3	15.0
	TOTAL	20	100.0

Mean	2.300	Median	3.000	Std Dev	1.174
Valid Cases	20	Missing Cases	0		

Table #26

T2008 Task 2008 Evasive Maneuvers

	Value	Frequency	Percent
U	1	2	10.0
C	2	4	20.0
B	3	12	60.0
A	4	2	10.0
	TOTAL	20	100.0

Mean	2.700	Median	3.000	Std Dev	.801
Valid Cases	20	Missing Cases	0		

Table #27

T2009 Task 2009 Multiaircraft Operations

	Value	Frequency	Percent
U	1	2	10.0
C	2	5	25.0
B	3	12	60.0
A	4	1	5.0
	TOTAL	20	100.0

Mean	2.600	Median	3.000	Std Dev	.754
Valid Cases	20	Missing Cases	0		

Table #28

T2016 Task 2016 Perform External Load Operations

	Value	Frequency	Percent
U	1	4	20.0
C	2	4	20.0
B	3	12	60.0
	TOTAL	20	100.0

Mean	2.400	Median	3.000	Std Dev	.821
Valid Cases	20	Missing Cases	0		

Table #29

T2081 Task 2081 Perform Terrain Flight

	Value	Frequency	Percent
U	1	4	20.0
C	2	5	25.0
B	3	9	45.0
A	4	2	10.0
	TOTAL	20	100.0

Mean	2.450	Median	3.000	Std Dev	.945
Valid Cases	20	Missing Cases	0		

Table #30

T2084 Task 2084 Perform Terrain Flight Approach

	Value	Frequency	Percent
U	1	1	5.0
C	2	7	35.0
B	3	11	55.0
A	4	1	5.0
	TOTAL	20	100.0

Mean 2.600 Median 3.000 Std Dev .681
Valid Cases 20 Missing Cases 0

APPENDIX E

Bivariate Correlation Tables for Army CMAQ "Logical" Subscales and Other Variables

CMQALL SCALE

Correlations:	ATMALL	ATM_13	ATM_12	TASK1071	BIGRADE	ACEALL	TEAMACE	XMNITOR	INFOEXC	WORKMNG	GLOBAL
PCONLY	-.1157	-.1101	-.1077	-.0763	-.0429	-.1579	-.0583	-.3169	-.3014	.0995	-.1613
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .627	P= .644	P= .651	P= .749	P= .858	P= .506	P= .807	P= .173	P= .197	P= .676	P= .497
PIONLY	.0640	.1902	.1508	.2959	.0283	.1057	-.0222	.0913	.1106	.1794	.1430
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .789	P= .422	P= .526	P= .205	P= .906	P= .657	P= .926	P= .702	P= .642	P= .449	P= .547
PCANDPI	-.0256	.0636	.0382	.1557	-.0063	-.0225	-.0499	-.1272	-.1049	.1815	.0009
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .915	P= .790	P= .873	P= .512	P= .979	P= .925	P= .834	P= .593	P= .660	P= .444	P= .997
DBL_PC	-.0631	-.0015	-.0174	.0734	-.0213	-.0779	-.0565	-.2110	-.1899	.1606	-.0636
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .792	P= .995	P= .942	P= .758	P= .929	P= .744	P= .813	P= .372	P= .423	P= .499	P= .790
ABSDIF	-.3265	-.2469	-.2593	-.0975	-.4258	-.1751	-.2197	-.3911	-.0444	-.1123	-.0885
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .160	P= .294	P= .270	P= .683	P= .061	P= .460	P= .352	P= .088	P= .853	P= .637	P= .711
REALDIF	-.1409	-.2441	-.2088	-.3087	-.0562	-.2079	-.0247	-.3145	-.3194	-.0783	-.2422
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .553	P= .300	P= .377	P= .185	P= .814	P= .379	P= .918	P= .177	P= .170	P= .743	P= .303
AD_BAD	.1295	.1709	.1543	.1823	.1926	.0617	.0583	.0700	-.0716	.2120	.0420
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .586	P= .471	P= .516	P= .442	P= .416	P= .796	P= .807	P= .769	P= .764	P= .370	P= .861
AD_GOOD	-.1761	-.0595	-.0878	.0925	-.2056	-.1022	-.1475	-.2967	-.1140	.1084	-.0408
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .458	P= .803	P= .713	P= .698	P= .384	P= .668	P= .535	P= .204	P= .632	P= .649	P= .864
DBL_BAD	.0314	.1053	.0825	.1699	.0676	.0083	-.0110	-.0573	-.0954	.1979	.0162
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .895	P= .659	P= .729	P= .474	P= .777	P= .972	P= .963	P= .810	P= .689	P= .403	P= .946
DBL_GOOD	-.0820	.0198	-.0074	.1367	-.0803	-.0526	-.0875	-.1936	-.1112	.1595	-.0145
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .731	P= .934	P= .975	P= .566	P= .736	P= .826	P= .714	P= .413	P= .641	P= .502	P= .952

CMQALL SCALE

Correlations:	NAVTIME	DEVIATE#	%OFFCOUR	WITHIN	THRT#	THRTIME	THRTMAX	MEANDUR	ILSRIGHT
PCONLY	-.2798 (19) P= .246	-.1061 (19) P= .666	-.0572 (19) P= .816	.2137 (19) P= .380	-.3537 (19) P= .137	-.1913 (19) P= .433	.2570 (19) P= .288	.1748 (19) P= .474	-.2547 (18) P= .308
PIONLY	-.1181 (19) P= .630	.0636 (19) P= .796	-.1875 (19) P= .442	-.2604 (19) P= .282	-.1009 (19) P= .681	-.1440 (19) P= .556	.0129 (19) P= .958	-.1152 (19) P= .639	.2816 (18) P= .258
PCANDPI	-.2476 (19) P= .307	-.0200 (19) P= .935	-.1621 (19) P= .507	-.0500 (19) P= .839	-.2801 (19) P= .246	-.2125 (19) P= .383	.1623 (19) P= .507	.0258 (19) P= .916	.0399 (18) P= .875
DBL_PC	-.2766 (19) P= .252	-.0556 (19) P= .821	-.1309 (19) P= .593	.0518 (19) P= .833	-.3277 (19) P= .171	-.2179 (19) P= .370	.2106 (19) P= .387	.0869 (19) P= .724	-.0755 (18) P= .766
ABSDIF	.0332 (19) P= .893	.1335 (19) P= .586	-.0430 (19) P= .861	-.2374 (19) P= .328	.0314 (19) P= .898	-.0524 (19) P= .831	.0196 (19) P= .937	-.0964 (19) P= .695	-.4211 (18) P= .082
REALDIF	-.1079 (19) P= .660	-.1331 (19) P= .587	.1168 (19) P= .634	.3805 (19) P= .108	-.1776 (19) P= .467	-.0200 (19) P= .935	.1804 (19) P= .460	.2281 (19) P= .348	-.4247 (18) P= .079
AD_BAD	-.2324 (19) P= .338	-.0790 (19) P= .748	-.1222 (19) P= .618	.0656 (19) P= .790	-.2600 (19) P= .282	-.1621 (19) P= .507	.1333 (19) P= .587	.0671 (19) P= .785	.2272 (18) P= .365
AD_GOOD	-.2058 (19) P= .398	.0449 (19) P= .855	-.1651 (19) P= .499	-.1562 (19) P= .523	-.2355 (19) P= .332	-.2145 (19) P= .378	.1543 (19) P= .528	-.0222 (19) P= .928	-.1688 (18) P= .503
DBL_BAD	-.2487 (19) P= .305	-.0425 (19) P= .863	-.1516 (19) P= .536	-.0082 (19) P= .973	-.2802 (19) P= .245	-.1994 (19) P= .413	.1559 (19) P= .524	.0419 (19) P= .865	.1119 (18) P= .659
DBL_GOOD	-.2392 (19) P= .324	.0034 (19) P= .989	-.1677 (19) P= .492	-.0906 (19) P= .712	-.2715 (19) P= .261	-.2192 (19) P= .367	.1639 (19) P= .503	.0088 (19) P= .971	-.0352 (18) P= .890

TEAMCMAQ SCALE

Correlations:	ATMALL	ATM_13	ATM_12	TASK1071	BIGRADE	ACEALL	TEAMACE	XMNITOR	INFOEXC	WORKMNG	GLOBAL
PCONLY	-.0450 (20) P= .851	-.0314 (20) P= .896	.0048 (20) P= .984	-.1910 (20) P= .420	-.0430 (20) P= .857	-.0041 (20) P= .986	.0863 (20) P= .717	-.1022 (20) P= .668	-.1431 (20) P= .547	.1566 (20) P= .510	-.1064 (20) P= .655
PIONLY	.0353 (20) P= .883	.1009 (20) P= .672	.0323 (20) P= .893	.3791 (20) P= .099	.0271 (20) P= .910	.0349 (20) P= .884	-.0946 (20) P= .691	.0115 (20) P= .962	.1051 (20) P= .659	.0580 (20) P= .808	.0469 (20) P= .844
PCANDPI	-.0018 (20) P= .994	.0552 (20) P= .817	.0269 (20) P= .911	.1619 (20) P= .495	-.0067 (20) P= .978	.0233 (20) P= .922	-.0164 (20) P= .945	-.0550 (20) P= .818	-.0112 (20) P= .963	.1403 (20) P= .555	-.0314 (20) P= .895
DBL_PC	-.0200 (20) P= .933	.0239 (20) P= .920	.0200 (20) P= .933	.0289 (20) P= .904	-.0224 (20) P= .925	.0139 (20) P= .954	.0250 (20) P= .917	-.0795 (20) P= .739	-.0672 (20) P= .778	.1593 (20) P= .502	-.0654 (20) P= .784
ABSDIF	.0137 (20) P= .954	.0528 (20) P= .825	.0007 (20) P= .998	.2861 (20) P= .221	-.0983 (20) P= .680	-.0640 (20) P= .789	-.1820 (20) P= .443	-.0502 (20) P= .834	.0268 (20) P= .911	-.0587 (20) P= .806	.1121 (20) P= .638
REALDIF	-.0580 (20) P= .808	-.1010 (20) P= .672	-.0224 (20) P= .925	-.4284 (20) P= .060	-.0502 (20) P= .833	-.0304 (20) P= .899	.1327 (20) P= .577	-.0773 (20) P= .746	-.1789 (20) P= .450	.0584 (20) P= .807	-.1082 (20) P= .650
AD_BAD	-.0091 (20) P= .970	.0149 (20) P= .950	.0213 (20) P= .929	-.0296 (20) P= .902	.0496 (20) P= .836	.0546 (20) P= .819	.0886 (20) P= .710	-.0163 (20) P= .946	-.0240 (20) P= .920	.1459 (20) P= .539	-.0881 (20) P= .712
AD_GOOD	.0064 (20) P= .979	.0770 (20) P= .747	.0229 (20) P= .924	.3021 (20) P= .195	-.0628 (20) P= .793	-.0177 (20) P= .941	-.1196 (20) P= .615	-.0753 (20) P= .752	.0062 (20) P= .979	.0834 (20) P= .727	.0389 (20) P= .871
DBL_BAD	-.0048 (20) P= .984	.0414 (20) P= .862	.0258 (20) P= .914	.0924 (20) P= .698	.0155 (20) P= .948	.0368 (20) P= .878	.0248 (20) P= .917	-.0419 (20) P= .861	-.0168 (20) P= .944	.1485 (20) P= .532	-.0554 (20) P= .817
DBL_GOOD	.0013 (20) P= .996	.0663 (20) P= .781	.0266 (20) P= .911	.2243 (20) P= .342	-.0289 (20) P= .904	.0083 (20) P= .972	-.0575 (20) P= .810	-.0655 (20) P= .784	-.0049 (20) P= .984	.1246 (20) P= .601	-.0054 (20) P= .982

TEAMCMAQ SCALE

Correlations:	NAVTIME	DEVIATE#	%OFFCOUR	WITHIN	THRT#	THRTIME	THRTMAX	MEANDUR	ILSRIGHT
PCONLY	-.1083 (19) P= .659	-.2234 (19) P= .358	-.1840 (19) P= .451	.0762 (19) P= .757	-.1436 (19) P= .557	-.0718 (19) P= .770	.1426 (19) P= .560	.0287 (19) P= .907	-.0422 (18) P= .868
PIONLY	-.0694 (19) P= .778	.0580 (19) P= .814	-.1041 (19) P= .671	-.2298 (19) P= .344	-.1903 (19) P= .435	-.2028 (19) P= .405	.0044 (19) P= .986	-.1006 (19) P= .682	.1314 (18) P= .603
PCANDPI	-.1188 (19) P= .628	-.0948 (19) P= .700	-.1915 (19) P= .432	-.1246 (19) P= .611	-.2309 (19) P= .342	-.1958 (19) P= .422	.0914 (19) P= .710	-.0574 (19) P= .816	.0722 (18) P= .776
DBL_PC	-.1250 (19) P= .610	-.1568 (19) P= .522	-.2055 (19) P= .399	-.0521 (19) P= .832	-.2152 (19) P= .376	-.1617 (19) P= .508	.1208 (19) P= .622	-.0267 (19) P= .914	.0334 (18) P= .895
ABSDIF	.1780 (19) P= .466	.2630 (19) P= .277	.1512 (19) P= .537	-.1565 (19) P= .522	.0214 (19) P= .931	-.0775 (19) P= .752	-.1457 (19) P= .552	-.1556 (19) P= .525	-.0686 (18) P= .787
REALDIF	-.0162 (19) P= .948	-.1934 (19) P= .427	-.0383 (19) P= .876	.2332 (19) P= .337	.0569 (19) P= .817	.1142 (19) P= .642	.0905 (19) P= .713	.0990 (19) P= .687	-.1426 (18) P= .572
AD_BAD	-.1959 (19) P= .422	-.2245 (19) P= .356	-.2392 (19) P= .324	-.0120 (19) P= .961	-.1978 (19) P= .417	-.1138 (19) P= .643	.1556 (19) P= .525	.0415 (19) P= .866	.0957 (18) P= .706
AD_GOOD	.0050 (19) P= .984	.0747 (19) P= .761	-.0714 (19) P= .772	-.1954 (19) P= .423	-.1802 (19) P= .460	-.2087 (19) P= .391	-.0089 (19) P= .971	-.1388 (19) P= .571	.0280 (18) P= .912
DBL_BAD	-.1548 (19) P= .527	-.1508 (19) P= .538	-.2190 (19) P= .368	-.0850 (19) P= .729	-.2278 (19) P= .348	-.1716 (19) P= .482	.1211 (19) P= .622	-.0203 (19) P= .934	.0835 (18) P= .742
DBL_GOOD	-.0758 (19) P= .758	-.0327 (19) P= .894	-.1534 (19) P= .531	-.1583 (19) P= .518	-.2219 (19) P= .361	-.2102 (19) P= .388	.0563 (19) P= .819	-.0920 (19) P= .708	.0580 (18) P= .819

CREWFAL SCALE

Correlations:	ATMALL	ATM_13	ATM_12	TASK1071	BIGRADE	ACEALL	TEAMACE	XMNITOR	INFOEXC	WORKMNG	GLOBAL
PCONLY	-.0420	.0373	.0141	.1384	.0565	-.1496	-.1052	-.2649	-.2253	.0393	-.0928
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .861	P= .876	P= .953	P= .561	P= .813	P= .529	P= .659	P= .259	P= .340	P= .869	P= .697
PIONLY	.1262	.2972	.2848	.2234	.1735	.2439	.1029	.1111	.2716	.3087	.1475
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .596	P= .203	P= .224	P= .344	P= .464	P= .300	P= .666	P= .641	P= .247	P= .185	P= .535
PCANDPI	.0509	.2006	.1793	.2162	.1377	.0577	-.0006	-.0904	.0295	.2087	.0335
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .831	P= .396	P= .449	P= .360	P= .563	P= .809	P= .998	P= .705	P= .902	P= .377	P= .888
DBL_PC	.0170	.1455	.1226	.1949	.1118	-.0202	-.0412	-.1617	-.0680	.1516	-.0141
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .943	P= .540	P= .607	P= .410	P= .639	P= .933	P= .863	P= .496	P= .776	P= .524	P= .953
ABSDIF	-.3228	-.2093	-.1471	-.4375	-.2033	-.1640	-.2458	-.0637	-.1543	-.0907	-.2177
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .165	P= .376	P= .536	P= .054	P= .390	P= .490	P= .296	P= .790	P= .516	P= .704	P= .356
REALDIF	-.1544	-.2399	-.2496	-.0799	-.1085	-.3609	-.1905	-.3434	-.4552	-.2487	-.2204
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .516	P= .308	P= .289	P= .738	P= .649	P= .118	P= .421	P= .138	P= .044	P= .290	P= .350
AD_BAD	.1705	.2546	.2118	.3576	.1981	.1140	.0961	-.0526	.0859	.2149	.1144
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .472	P= .279	P= .370	P= .122	P= .402	P= .632	P= .687	P= .826	P= .719	P= .363	P= .631
AD_GOOD	-.0939	.1017	.1087	.0155	.0433	-.0168	-.1097	-.1160	-.0399	.1622	-.0641
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .694	P= .670	P= .648	P= .948	P= .856	P= .944	P= .645	P= .626	P= .867	P= .495	P= .788
DBL_BAD	.0967	.2246	.1949	.2733	.1629	.0799	.0356	-.0779	.0512	.2149	.0645
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .685	P= .341	P= .410	P= .244	P= .493	P= .738	P= .881	P= .744	P= .830	P= .363	P= .787
DBL_GOOD	.0017	.1709	.1590	.1514	.1081	.0332	-.0386	-.1014	.0060	.1974	.0003
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .994	P= .471	P= .503	P= .524	P= .650	P= .890	P= .872	P= .670	P= .980	P= .404	P= .999

CREWFAL SCALE

Correlations:	NAVTIME	DEVIATE#	%OFFCOUR	WITHIN	THRT#	THRTIME	THRTMAX	MEANDUR	ILSRIGHT
PCONLY	-.0855 (19) P= .728	.1069 (19) P= .663	.1302 (19) P= .595	.0135 (19) P= .956	-.3319 (19) P= .165	-.1491 (19) P= .542	.3525 (19) P= .139	.3040 (19) P= .206	-.0308 (18) P= .903
PIONLY	-.0508 (19) P= .836	-.2644 (19) P= .274	-.2020 (19) P= .407	-.0734 (19) P= .765	-.1826 (19) P= .454	-.2099 (19) P= .388	-.0212 (19) P= .931	-.0257 (19) P= .917	.3501 (18) P= .154
PCANDPI	-.0810 (19) P= .742	-.0946 (19) P= .700	-.0435 (19) P= .860	-.0359 (19) P= .884	-.3055 (19) P= .203	-.2136 (19) P= .380	.1960 (19) P= .421	.1646 (19) P= .501	.1886 (18) P= .454
DBL_PC	-.0859 (19) P= .727	-.0204 (19) P= .934	.0219 (19) P= .929	-.0182 (19) P= .941	-.3278 (19) P= .171	-.1972 (19) P= .418	.2643 (19) P= .274	.2251 (19) P= .354	.1095 (18) P= .665
ABSDIF	.0925 (19) P= .706	.0665 (19) P= .787	.0977 (19) P= .691	-.3072 (19) P= .201	.2237 (19) P= .357	.1725 (19) P= .480	.1668 (19) P= .495	.0203 (19) P= .934	.3350 (18) P= .174
REALDIF	-.0314 (19) P= .898	.3437 (19) P= .150	.3073 (19) P= .201	.0805 (19) P= .743	-.1358 (19) P= .579	.0576 (19) P= .815	.3439 (19) P= .149	.3036 (19) P= .206	-.3351 (18) P= .174
AD_BAD	-.1059 (19) P= .666	-.1073 (19) P= .662	-.0758 (19) P= .758	.0900 (19) P= .714	-.3503 (19) P= .142	-.2512 (19) P= .299	.1028 (19) P= .676	.1334 (19) P= .586	.0215 (18) P= .933
AD_GOOD	-.0374 (19) P= .879	-.0622 (19) P= .800	.0011 (19) P= .996	-.1712 (19) P= .483	-.1970 (19) P= .419	-.1306 (19) P= .594	.2642 (19) P= .274	.1687 (19) P= .490	.3427 (18) P= .164
DBL_BAD	-.0918 (19) P= .709	-.1011 (19) P= .680	-.0564 (19) P= .818	.0106 (19) P= .966	-.3280 (19) P= .170	-.2317 (19) P= .340	.1647 (19) P= .500	.1560 (19) P= .524	.1287 (18) P= .611
DBL_GOOD	-.0677 (19) P= .783	-.0855 (19) P= .728	-.0290 (19) P= .906	-.0838 (19) P= .733	-.2749 (19) P= .255	-.1898 (19) P= .437	.2244 (19) P= .356	.1699 (19) P= .487	.2473 (18) P= .322

GIVEGET SCALE

Correlations:	ATMALL	ATM_13	ATM_12	TASK1071	BIGRADE	ACEALL	TEAMACE	XMNITOR	INFOEXC	WORKMNG	GLOBAL
PCONLY	-.1093 (20) P= .646	-.1898 (20) P= .423	-.2159 (20) P= .361	.0061 (20) P= .980	-.0429 (20) P= .857	-.0551 (20) P= .817	.0218 (20) P= .927	-.2885 (20) P= .217	-.1295 (20) P= .586	.1300 (20) P= .585	-.0611 (20) P= .798
PIONLY	-.0570 (20) P= .811	-.0371 (20) P= .877	-.0801 (20) P= .737	.1902 (20) P= .422	-.1080 (20) P= .650	-.0112 (20) P= .963	-.1602 (20) P= .500	.1231 (20) P= .605	-.0077 (20) P= .974	.0481 (20) P= .841	.1319 (20) P= .579
PCANDPI	-.1178 (20) P= .621	-.1589 (20) P= .503	-.2087 (20) P= .377	.1446 (20) P= .543	-.1094 (20) P= .646	-.0465 (20) P= .846	-.1031 (20) P= .665	-.1091 (20) P= .647	-.0954 (20) P= .689	.1255 (20) P= .598	.0550 (20) P= .818
DBL_PC	-.1245 (20) P= .601	-.1869 (20) P= .430	-.2305 (20) P= .328	.0957 (20) P= .688	-.0895 (20) P= .707	-.0545 (20) P= .820	-.0566 (20) P= .813	-.1988 (20) P= .401	-.1191 (20) P= .617	.1387 (20) P= .560	.0081 (20) P= .973
ABSDIF	-.3345 (20) P= .149	-.3128 (20) P= .179	-.3365 (20) P= .147	-.0764 (20) P= .749	-.3934 (20) P= .086	-.1764 (20) P= .457	-.1505 (20) P= .527	-.4293 (20) P= .059	-.1096 (20) P= .646	-.0711 (20) P= .766	-.1132 (20) P= .635
REALDIF	-.0329 (20) P= .891	-.1017 (20) P= .670	-.0884 (20) P= .711	-.1329 (20) P= .576	.0488 (20) P= .838	-.0292 (20) P= .903	.1302 (20) P= .584	-.2839 (20) P= .225	-.0821 (20) P= .731	.0533 (20) P= .823	-.1363 (20) P= .567
AD_BAD	.0910 (20) P= .703	.0438 (20) P= .854	.0151 (20) P= .950	.1661 (20) P= .484	.1317 (20) P= .580	.0613 (20) P= .798	-.0015 (20) P= .995	.1524 (20) P= .521	-.0183 (20) P= .939	.1469 (20) P= .537	.1111 (20) P= .641
AD_GOOD	-.2788 (20) P= .234	-.3004 (20) P= .198	-.3538 (20) P= .126	.0757 (20) P= .751	-.3042 (20) P= .192	-.1343 (20) P= .572	-.1662 (20) P= .484	-.3236 (20) P= .164	-.1375 (20) P= .563	.0631 (20) P= .791	-.0173 (20) P= .942
DBL_BAD	-.0421 (20) P= .860	-.0874 (20) P= .714	-.1312 (20) P= .581	.1593 (20) P= .502	-.0208 (20) P= .931	-.0068 (20) P= .977	-.0683 (20) P= .775	-.0126 (20) P= .958	-.0698 (20) P= .770	.1394 (20) P= .558	.0792 (20) P= .740
DBL_GOOD	-.1864 (20) P= .431	-.2214 (20) P= .348	-.2747 (20) P= .241	.1232 (20) P= .605	-.1911 (20) P= .420	-.0832 (20) P= .727	-.1323 (20) P= .578	-.1986 (20) P= .401	-.1160 (20) P= .626	.1059 (20) P= .657	.0286 (20) P= .905

GIVEGET SCALE

Correlations:	NAVTIME	DEVIATE#	%OFFCOUR	WITHIN	THRT#	THRTIME	THRTMAX	MEANDUR	ILSRIGHT
PCONLY	-.4336	-.2121	-.1106	.5136	-.3782	-.2404	.1469	.1558	-.5031
	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(18)
	P= .064	P= .383	P= .652	P= .025	P= .110	P= .322	P= .548	P= .524	P= .033
PIONLY	-.1228	.2710	-.1996	-.1892	.0428	.0131	.0354	-.0957	.0916
	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(18)
	P= .616	P= .262	P= .413	P= .438	P= .862	P= .957	P= .886	P= .697	P= .718
PCANDPI	-.3937	.0524	-.2250	.2186	-.2324	-.1581	.1288	.0380	-.2760
	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(18)
	P= .095	P= .831	P= .354	P= .369	P= .338	P= .518	P= .599	P= .877	P= .268
DBL_PC	-.4470	-.0614	-.1939	.3705	-.3187	-.2092	.1485	.0942	-.4021
	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(18)
	P= .055	P= .803	P= .426	P= .118	P= .184	P= .390	P= .544	P= .701	P= .098
ABSDIF	-.1521	.1463	-.1227	-.1367	-.0933	-.1377	-.0560	-.0912	-.5647
	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(18)
	P= .534	P= .550	P= .617	P= .577	P= .704	P= .574	P= .820	P= .710	P= .015
REALDIF	-.2048	-.3369	.0682	.4819	-.2858	-.1716	.0738	.1736	-.4024
	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(18)
	P= .400	P= .158	P= .782	P= .037	P= .236	P= .482	P= .764	P= .477	P= .098
AD_BAD	-.2456	-.0371	-.1205	.2590	-.1431	-.0562	.1390	.0823	.0908
	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(18)
	P= .311	P= .880	P= .623	P= .284	P= .559	P= .819	P= .570	P= .738	P= .720
AD_GOOD	-.4103	.1239	-.2541	.1064	-.2442	-.2068	.0762	-.0185	-.5379
	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(18)
	P= .081	P= .613	P= .294	P= .665	P= .314	P= .396	P= .757	P= .940	P= .021
DBL_BAD	-.3525	.0198	-.1937	.2434	-.2073	-.1250	.1381	.0568	-.1453
	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(18)
	P= .139	P= .936	P= .427	P= .315	P= .394	P= .610	P= .573	P= .817	P= .565
DBL_GOOD	-.4163	.0825	-.2456	.1836	-.2465	-.1836	.1135	.0174	-.3914
	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(18)
	P= .076	P= .737	P= .311	P= .452	P= .309	P= .452	P= .644	P= .944	P= .108

HLPCMAQ SCALE

Correlations:	ATMALL	ATM_13	ATM_12	TASK1071	BIGRADE	ACEALL	TEAMACE	XMNITOR	INFOEXC	WORKMNG	GLOBAL
PCONLY	-.2299	-.2498	-.2208	-.2839	-.1647	-.3878	-.2689	-.4139	-.5766	-.0666	-.3186
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .330	P= .288	P= .349	P= .225	P= .488	P= .091	P= .252	P= .070	P= .008	P= .780	P= .171
PIONLY	.1183	.1641	.1344	.2412	.0127	.0307	-.0179	.0449	-.0064	.1036	.0885
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .619	P= .489	P= .572	P= .306	P= .958	P= .898	P= .940	P= .851	P= .979	P= .664	P= .711
PCANDPI	-.0526	-.0329	-.0364	.0000	-.0870	-.2042	-.1685	-.2098	-.3393	.0321	-.1246
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .826	P= .890	P= .879	P=1.000	P= .715	P= .388	P= .478	P= .375	P= .143	P= .893	P= .601
DBL_PC	-.1253	-.1198	-.1108	-.1110	-.1229	-.2891	-.2185	-.3030	-.4538	-.0044	-.2084
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .599	P= .615	P= .642	P= .641	P= .606	P= .216	P= .355	P= .194	P= .044	P= .985	P= .378
ABSDIF	-.5630	-.5848	-.5954	-.3043	-.7627	-.3776	-.2443	-.5721	-.2535	-.3951	-.3370
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .010	P= .007	P= .006	P= .192	P= .000	P= .101	P= .299	P= .008	P= .281	P= .085	P= .146
REALDIF	-.2746	-.3295	-.2820	-.4225	-.1337	-.3154	-.1844	-.3473	-.4234	-.1403	-.3145
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .241	P= .156	P= .228	P= .064	P= .574	P= .175	P= .436	P= .134	P= .063	P= .555	P= .177
AD_BAD	.2072	.2346	.2363	.1373	.2668	-.0112	-.0395	.0716	-.1873	.2068	.0413
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .381	P= .320	P= .316	P= .564	P= .256	P= .962	P= .869	P= .764	P= .429	P= .382	P= .863
AD_GOOD	-.3025	-.2948	-.3027	-.1381	-.4238	-.3540	-.2615	-.4472	-.4185	-.1505	-.2643
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .195	P= .207	P= .195	P= .562	P= .063	P= .126	P= .265	P= .048	P= .066	P= .526	P= .260
DBL_BAD	.0419	.0650	.0634	.0507	.0414	-.1382	-.1252	-.1113	-.2919	.0975	-.0666
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .861	P= .785	P= .791	P= .832	P= .862	P= .561	P= .599	P= .640	P= .212	P= .683	P= .780
DBL_GOOD	-.1459	-.1301	-.1353	-.0508	-.2132	-.2646	-.2071	-.3026	-.3773	-.0342	-.1792
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .539	P= .585	P= .570	P= .832	P= .367	P= .260	P= .381	P= .195	P= .101	P= .886	P= .450

HLPCMAQ SCALE

Correlations:	NAVTIME	DEVIATE#	%OFFCOUR	WITHIN	THRT#	THRTIME	THRTMAX	MEANDUR	ILSRIGHT
PCONLY	-.3368	.0073	-.0228	.0900	-.2649	-.1546	.1166	-.0019	-.2785
	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(18)
	P= .159	P= .976	P= .926	P= .714	P= .273	P= .528	P= .634	P= .994	P= .263
PIONLY	-.2992	.1069	-.1226	-.2631	-.0526	-.1115	-.0590	-.0927	.2555
	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(18)
	P= .213	P= .663	P= .617	P= .277	P= .831	P= .650	P= .810	P= .706	P= .306
PCANDPI	-.3971	.0768	-.0964	-.1267	-.1883	-.1647	.0272	-.0640	.0057
	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(18)
	P= .092	P= .755	P= .695	P= .605	P= .440	P= .500	P= .912	P= .795	P= .982
DBL_PC	-.3983	.0545	-.0738	-.0504	-.2297	-.1710	.0636	-.0438	-.1081
	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(18)
	P= .091	P= .824	P= .764	P= .838	P= .344	P= .484	P= .796	P= .859	P= .669
ABSDIF	.2233	.2399	.0504	-.1554	.2306	.2167	.2502	.0321	-.4251
	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(18)
	P= .358	P= .323	P= .838	P= .525	P= .342	P= .373	P= .302	P= .896	P= .079
REALDIF	.0117	-.0893	.0916	.3011	-.1529	-.0175	.1402	.0808	-.4217
	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(18)
	P= .962	P= .716	P= .709	P= .210	P= .532	P= .943	P= .567	P= .742	P= .081
AD_BAD	-.4538	-.0399	-.1084	-.0426	-.2715	-.2442	-.0887	-.0713	.1968
	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(18)
	P= .051	P= .871	P= .659	P= .863	P= .261	P= .314	P= .718	P= .772	P= .434
AD_GOOD	-.2539	.1775	-.0633	-.1838	-.0638	-.0490	.1378	-.0427	-.1939
	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(18)
	P= .294	P= .467	P= .797	P= .451	P= .795	P= .842	P= .574	P= .862	P= .441
DBL_BAD	-.4283	.0356	-.1033	-.0989	-.2239	-.1983	-.0149	-.0683	.0773
	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(18)
	P= .067	P= .885	P= .674	P= .687	P= .357	P= .416	P= .952	P= .781	P= .761
DBL_GOOD	-.3548	.1158	-.0867	-.1510	-.1474	-.1264	.0686	-.0578	-.0671
	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(19)	(18)
	P= .136	P= .637	P= .724	P= .537	P= .547	P= .606	P= .780	P= .814	P= .791

APPENDIX F

Bivariate Correlation Tables for Army CMAQ "Factor" Subscales and Other Variables

CMAQ34 SCALE

Correlations:	ATMALL	ATM_13	ATM_12	TASK1071	BIGRADE	ACEALL	TEAMACE	XMNITOR	INFOEXC	WORKMNG	GLOBAL
PCONLY	-.0440 (20) P= .854	-.0837 (20) P= .726	-.0993 (20) P= .677	.0248 (20) P= .917	-.0235 (20) P= .922	-.0675 (20) P= .777	.0057 (20) P= .981	-.2389 (20) P= .310	-.1918 (20) P= .418	.1576 (20) P= .507	-.0832 (20) P= .727
PIONLY	.0164 (20) P= .945	.1195 (20) P= .616	.0807 (20) P= .735	.2500 (20) P= .288	.0373 (20) P= .876	.0960 (20) P= .687	-.0657 (20) P= .783	.1190 (20) P= .617	.0935 (20) P= .695	.1933 (20) P= .414	.1433 (20) P= .547
PCANDPI	-.0151 (20) P= .950	.0316 (20) P= .895	-.0042 (20) P= .986	.1855 (20) P= .434	.0114 (20) P= .962	.0253 (20) P= .916	-.0415 (20) P= .862	-.0614 (20) P= .797	-.0508 (20) P= .832	.2262 (20) P= .338	.0482 (20) P= .840
DBL_PC	-.0276 (20) P= .908	-.0123 (20) P= .959	-.0424 (20) P= .859	.1336 (20) P= .574	-.0017 (20) P= .994	-.0100 (20) P= .967	-.0254 (20) P= .915	-.1362 (20) P= .567	-.1103 (20) P= .643	.2137 (20) P= .366	-.0010 (20) P= .997
ABSDIF	-.2171 (20) P= .358	-.1496 (20) P= .529	-.1563 (20) P= .511	-.0735 (20) P= .758	-.2174 (20) P= .357	-.0048 (20) P= .984	-.0967 (20) P= .685	-.2604 (20) P= .268	.0793 (20) P= .740	.1143 (20) P= .631	.0727 (20) P= .761
REALDIF	-.0466 (20) P= .845	-.1637 (20) P= .490	-.1423 (20) P= .549	-.1939 (20) P= .413	-.0491 (20) P= .837	-.1317 (20) P= .580	.0600 (20) P= .801	-.2786 (20) P= .234	-.2219 (20) P= .347	-.0471 (20) P= .844	-.1836 (20) P= .439
AD_BAD	.0897 (20) P= .707	.0991 (20) P= .678	.0705 (20) P= .768	.1999 (20) P= .398	.1134 (20) P= .634	.0247 (20) P= .918	.0091 (20) P= .970	.0691 (20) P= .772	-.0828 (20) P= .728	.1468 (20) P= .537	.0083 (20) P= .972
AD_GOOD	-.1146 (20) P= .630	-.0422 (20) P= .860	-.0767 (20) P= .748	.1280 (20) P= .591	-.0916 (20) P= .701	.0199 (20) P= .934	-.0815 (20) P= .733	-.1754 (20) P= .459	-.0073 (20) P= .975	.2513 (20) P= .285	.0761 (20) P= .750
DBL_BAD	.0233 (20) P= .922	.0575 (20) P= .810	.0233 (20) P= .922	.1962 (20) P= .407	.0495 (20) P= .836	.0258 (20) P= .914	-.0240 (20) P= .920	-.0149 (20) P= .950	-.0641 (20) P= .788	.2033 (20) P= .390	.0348 (20) P= .884
DBL_GOOD	-.0527 (20) P= .825	.0049 (20) P= .984	-.0314 (20) P= .895	.1692 (20) P= .476	-.0267 (20) P= .911	.0240 (20) P= .920	-.0576 (20) P= .809	-.1057 (20) P= .657	-.0360 (20) P= .880	.2419 (20) P= .304	.0600 (20) P= .802

CMAQ34 SCALE

Correlations:	NAVTIME	DEVIATE#	%OFFCOUR	WITHIN	THRT#	THRTIME	THRTMAX	MEANDUR	ILSRIGHT
PCONLY	-.3870 (19) P= .102	-.1416 (19) P= .563	-.1561 (19) P= .523	.3177 (19) P= .185	-.3924 (19) P= .097	-.2603 (19) P= .282	.1295 (19) P= .597	.0794 (19) P= .747	-.3389 (18) P= .169
PIONLY	-.1641 (19) P= .502	.1244 (19) P= .612	-.2318 (19) P= .340	-.2452 (19) P= .312	-.0977 (19) P= .691	-.1701 (19) P= .486	-.0656 (19) P= .790	-.1879 (19) P= .441	.2592 (18) P= .299
PCANDPI	-.3419 (19) P= .152	.0011 (19) P= .997	-.2512 (19) P= .300	.0207 (19) P= .933	-.2996 (19) P= .213	-.2708 (19) P= .262	.0320 (19) P= .897	-.0814 (19) P= .740	-.0191 (18) P= .940
DBL_PC	-.3822 (19) P= .106	-.0555 (19) P= .822	-.2299 (19) P= .344	.1399 (19) P= .568	-.3560 (19) P= .135	-.2843 (19) P= .238	.0728 (19) P= .767	-.0229 (19) P= .926	-.1465 (18) P= .562
ABSDIF	-.1756 (19) P= .472	.0289 (19) P= .907	-.2439 (19) P= .314	-.1731 (19) P= .479	-.0704 (19) P= .775	-.1899 (19) P= .436	-.1171 (19) P= .633	-.2158 (19) P= .375	-.3841 (18) P= .116
REALDIF	-.1467 (19) P= .549	-.2113 (19) P= .385	.0825 (19) P= .737	.4453 (19) P= .056	-.2075 (19) P= .394	-.0476 (19) P= .847	.1521 (19) P= .534	.2196 (19) P= .366	-.4704 (18) P= .049
AD_BAD	-.2204 (19) P= .365	-.0128 (19) P= .959	-.1073 (19) P= .662	.1007 (19) P= .682	-.2329 (19) P= .337	-.1504 (19) P= .539	.0841 (19) P= .732	.0303 (19) P= .902	.1576 (18) P= .532
AD_GOOD	-.3811 (19) P= .107	.0144 (19) P= .953	-.3338 (19) P= .163	-.0629 (19) P= .798	-.2950 (19) P= .220	-.3257 (19) P= .174	-.0268 (19) P= .913	-.1722 (19) P= .481	-.1969 (18) P= .434
DBL_BAD	-.3068 (19) P= .201	-.0040 (19) P= .987	-.2051 (19) P= .400	.0509 (19) P= .836	-.2836 (19) P= .239	-.2340 (19) P= .335	.0522 (19) P= .832	-.0424 (19) P= .863	.0464 (18) P= .855
DBL_GOOD	-.3661 (19) P= .123	.0061 (19) P= .980	-.2891 (19) P= .230	-.0100 (19) P= .968	-.3063 (19) P= .202	-.2989 (19) P= .214	.0109 (19) P= .965	-.1176 (19) P= .631	-.0848 (18) P= .738

COMMCOR SCALE

Correlations:	ATMALL	ATM_13	ATM_12	TASK1071	BIGRADE	ACEALL	TEAMACE	XMNITOR	INFOEXC	WORKMNG	GLOBAL
PCONLY	.2738	.1722	.1470	.2244	.3097	.1752	.2180	-.0873	.0270	.4098	.1810
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .243	P= .468	P= .536	P= .341	P= .184	P= .460	P= .356	P= .714	P= .910	P= .073	P= .445
PIONLY	-.1004	-.1224	-.1399	.0066	-.1235	.0249	-.1795	.1000	.0909	.0698	.0613
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .674	P= .607	P= .556	P= .978	P= .604	P= .917	P= .449	P= .675	P= .703	P= .770	P= .797
PCANDPI	.0890	.0096	-.0197	.1427	.0929	.1268	-.0072	.0249	.0878	.3057	.1589
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .709	P= .968	P= .934	P= .548	P= .697	P= .594	P= .976	P= .917	P= .713	P= .190	P= .503
DBL_PC	.1757	.0787	.0481	.1917	.1934	.1602	.0864	-.0195	.0714	.3810	.1846
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .459	P= .742	P= .840	P= .418	P= .414	P= .500	P= .717	P= .935	P= .765	P= .097	P= .436
ABSDIF	-.4298	-.4085	-.3969	-.3061	-.4130	-.3761	-.3331	-.4923	-.2725	-.3292	-.4263
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .059	P= .074	P= .083	P= .189	P= .070	P= .102	P= .151	P= .027	P= .245	P= .156	P= .061
REALDIF	.2490	.2035	.2018	.1336	.2895	.0887	.2771	-.1332	-.0553	.1984	.0635
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .290	P= .389	P= .394	P= .574	P= .216	P= .710	P= .237	P= .576	P= .817	P= .402	P= .790
AD_BAD	.2719	.1977	.1686	.2577	.2672	.2774	.1491	.2490	.1977	.4003	.3267
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .246	P= .403	P= .477	P= .273	P= .255	P= .236	P= .530	P= .290	P= .403	P= .080	P= .160
AD_GOOD	-.1486	-.2118	-.2330	-.0313	-.1358	-.0840	-.1868	-.2426	-.0648	.1095	-.0810
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .532	P= .370	P= .323	P= .896	P= .568	P= .725	P= .430	P= .303	P= .786	P= .646	P= .734
DBL_BAD	.1632	.0836	.0537	.1917	.1638	.1894	.0539	.1135	.1333	.3512	.2291
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .492	P= .726	P= .822	P= .418	P= .490	P= .424	P= .821	P= .634	P= .575	P= .129	P= .331
DBL_GOOD	.0067	-.0698	-.0972	.0853	.0140	.0556	-.0721	-.0705	.0361	.2463	.0784
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .978	P= .770	P= .684	P= .721	P= .953	P= .816	P= .763	P= .768	P= .880	P= .295	P= .743

COMMCOR SCALE

Correlations:	NAVTIME	DEVIATE#	%OFFCOUR	WITHIN	THRT#	THRTIME	THRTMAX	MEANDUR	ILSRIGHT
PCONLY	-.6174 (19) P= .005	-.4405 (19) P= .059	-.3171 (19) P= .186	.3077 (19) P= .200	-.3648 (19) P= .125	-.2786 (19) P= .248	.0459 (19) P= .852	.1431 (19) P= .559	-.3238 (18) P= .190
PIONLY	-.1179 (19) P= .631	.0507 (19) P= .837	-.4514 (19) P= .052	-.2403 (19) P= .322	.0834 (19) P= .734	-.0297 (19) P= .904	-.1487 (19) P= .543	-.3217 (19) P= .179	.1775 (18) P= .481
PCANDPI	-.4700 (19) P= .042	-.2291 (19) P= .345	-.5491 (19) P= .015	-.0012 (19) P= .996	-.1572 (19) P= .520	-.1936 (19) P= .427	-.0891 (19) P= .717	-.1659 (19) P= .497	-.0408 (18) P= .872
DBL_PC	-.5809 (19) P= .009	-.3417 (19) P= .152	-.5094 (19) P= .026	.1281 (19) P= .601	-.2606 (19) P= .281	-.2494 (19) P= .303	-.0418 (19) P= .865	-.0538 (19) P= .827	-.1586 (18) P= .530
ABSDIF	-.0556 (19) P= .821	.1014 (19) P= .680	.0439 (19) P= .858	-.3311 (19) P= .166	.0119 (19) P= .961	.0383 (19) P= .876	.1316 (19) P= .591	.0540 (19) P= .826	-.4188 (18) P= .084
REALDIF	-.2863 (19) P= .235	-.3112 (19) P= .195	.1628 (19) P= .505	.3798 (19) P= .109	-.2905 (19) P= .228	-.1478 (19) P= .546	.1462 (19) P= .550	.3431 (19) P= .150	-.3380 (18) P= .170
AD_BAD	-.3617 (19) P= .128	-.2349 (19) P= .333	-.4722 (19) P= .041	.1499 (19) P= .540	-.1349 (19) P= .582	-.1768 (19) P= .469	-.1333 (19) P= .586	-.1612 (19) P= .510	.1656 (18) P= .511
AD_GOOD	-.4694 (19) P= .043	-.1622 (19) P= .507	-.4920 (19) P= .032	-.1729 (19) P= .479	-.1412 (19) P= .564	-.1616 (19) P= .509	-.0152 (19) P= .951	-.1275 (19) P= .603	-.2632 (18) P= .291
DBL_BAD	-.4403 (19) P= .059	-.2374 (19) P= .328	-.5337 (19) P= .019	.0574 (19) P= .816	-.1526 (19) P= .533	-.1921 (19) P= .431	-.1086 (19) P= .658	-.1684 (19) P= .491	.0388 (18) P= .879
DBL_GOOD	-.4856 (19) P= .035	-.2128 (19) P= .382	-.5471 (19) P= .015	-.0630 (19) P= .798	-.1567 (19) P= .522	-.1886 (19) P= .439	-.0655 (19) P= .790	-.1577 (19) P= .519	-.1233 (18) P= .626

SHARLEAD SCALE

Correlations:	ATMALL	ATM_13	ATM_12	TASK1071	BIGRADE	ACEALL	TEAMACE	XMNITOR	INFOEXC	WORKMNG	GLOBAL
PCONLY	-.2009	-.2784	-.2629	-.2350	-.2628	-.2882	-.2088	-.3517	-.3878	-.0706	-.3258
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .396	P= .235	P= .263	P= .319	P= .263	P= .218	P= .377	P= .128	P= .091	P= .768	P= .161
PIONLY	.1760	.3120	.2686	.3823	.1547	.1598	.1772	.1253	.0344	.2635	.2659
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .458	P= .181	P= .252	P= .096	P= .515	P= .501	P= .455	P= .599	P= .885	P= .262	P= .257
PCANDPI	.0052	.0611	.0371	.1458	-.0531	-.0660	.0009	-.1358	-.2319	.1616	-.0071
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .983	P= .798	P= .876	P= .540	P= .824	P= .782	P= .997	P= .568	P= .325	P= .496	P= .976
DBL_PC	-.0858	-.0830	-.0920	-.0075	-.1520	-.1718	-.0922	-.2464	-.3263	.0761	-.1493
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .719	P= .728	P= .700	P= .975	P= .522	P= .469	P= .699	P= .295	P= .160	P= .750	P= .530
ABSDIF	-.0904	-.2287	-.2225	-.1655	-.1580	-.0477	-.0960	-.1749	.1038	-.1132	.0610
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .705	P= .332	P= .346	P= .486	P= .506	P= .842	P= .687	P= .461	P= .663	P= .635	P= .798
REALDIF	-.2554	-.4043	-.3625	-.4291	-.2783	-.2978	-.2612	-.3120	-.2673	-.2388	-.3997
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .277	P= .077	P= .116	P= .059	P= .235	P= .202	P= .266	P= .181	P= .255	P= .311	P= .081
AD_BAD	.0448	.1461	.1269	.1748	.0361	-.0231	.0444	-.0125	-.2052	.1617	-.0327
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .851	P= .539	P= .594	P= .461	P= .880	P= .923	P= .852	P= .958	P= .386	P= .496	P= .891
AD_GOOD	-.0645	-.1075	-.1304	.0403	-.1849	-.1139	-.0739	-.2941	-.1884	.0994	.0394
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .787	P= .652	P= .584	P= .866	P= .435	P= .633	P= .757	P= .208	P= .426	P= .677	P= .869
DBL_BAD	.0224	.0990	.0767	.1612	-.0156	-.0488	.0197	-.0852	-.2249	.1648	-.0183
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .925	P= .678	P= .748	P= .497	P= .948	P= .838	P= .934	P= .721	P= .340	P= .487	P= .939
DBL_GOOD	-.0167	.0110	-.0141	.1206	-.0981	-.0851	-.0229	-.1940	-.2314	.1511	.0073
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .944	P= .963	P= .953	P= .613	P= .681	P= .721	P= .924	P= .413	P= .326	P= .525	P= .976

SHARLEAD SCALE

Correlations:	NAVTIME	DEVIATE#	%OFFCOUR	WITHIN	THRT#	THRTIME	THRTMAX	MEANDUR	ILSRIGHT
PCONLY	-.2257 (19) P= .353	-.0512 (19) P= .835	-.1109 (19) P= .651	.1707 (19) P= .485	-.4031 (19) P= .087	-.2935 (19) P= .223	-.0134 (19) P= .957	-.0825 (19) P= .737	-.4271 (18) P= .077
PIONLY	-.3429 (19) P= .151	.1266 (19) P= .606	-.0084 (19) P= .973	-.1164 (19) P= .635	-.1075 (19) P= .661	-.1215 (19) P= .620	.1372 (19) P= .575	.0026 (19) P= .992	.3264 (18) P= .186
PCANDPI	-.4021 (19) P= .088	.0660 (19) P= .788	-.0744 (19) P= .762	.0151 (19) P= .951	-.3298 (19) P= .168	-.2734 (19) P= .257	.0974 (19) P= .692	-.0486 (19) P= .844	-.0620 (18) P= .807
DBL_PC	-.3678 (19) P= .121	.0236 (19) P= .924	-.0969 (19) P= .693	.0815 (19) P= .740	-.3925 (19) P= .096	-.3084 (19) P= .199	.0607 (19) P= .805	-.0674 (19) P= .784	-.2380 (18) P= .341
ABSDIF	.2094 (19) P= .390	-.0873 (19) P= .722	-.3017 (19) P= .209	-.0194 (19) P= .937	.2987 (19) P= .214	.1418 (19) P= .563	-.2580 (19) P= .286	-.2589 (19) P= .285	-.2614 (18) P= .295
REALDIF	.1297 (19) P= .597	-.1331 (19) P= .587	-.0637 (19) P= .796	.2008 (19) P= .410	-.1699 (19) P= .487	-.0894 (19) P= .716	-.1177 (19) P= .631	-.0544 (19) P= .825	-.5030 (18) P= .033
AD_BAD	-.3705 (19) P= .118	.0831 (19) P= .735	.0748 (19) P= .761	.0188 (19) P= .939	-.3573 (19) P= .133	-.2516 (19) P= .299	.1771 (19) P= .468	.0750 (19) P= .760	.0892 (18) P= .725
AD_GOOD	-.3325 (19) P= .164	.0164 (19) P= .947	-.3073 (19) P= .201	.0042 (19) P= .986	-.1811 (19) P= .458	-.2265 (19) P= .351	-.0691 (19) P= .779	-.2453 (19) P= .311	-.2679 (18) P= .282
DBL_BAD	-.3951 (19) P= .094	.0743 (19) P= .763	-.0125 (19) P= .959	.0169 (19) P= .945	-.3466 (19) P= .146	-.2685 (19) P= .266	.1326 (19) P= .588	.0029 (19) P= .991	.0023 (18) P= .993
DBL_GOOD	-.3985 (19) P= .091	.0537 (19) P= .827	-.1491 (19) P= .542	.0124 (19) P= .960	-.2987 (19) P= .214	-.2711 (19) P= .262	.0506 (19) P= .837	-.1110 (19) P= .651	-.1375 (18) P= .586

STRESS SCALE

Correlations:	ATMALL	ATM_13	ATM_12	TASK1071	BIGRADE	ACEALL	TEAMACE	XMNITOR	INFOEXC	WORKMNG	GLOBAL
PCONLY	-.1583	-.0595	-.0890	.0988	-.0743	-.0120	.0291	-.0812	-.0441	.0379	-.0126
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .505	P= .803	P= .709	P= .679	P= .755	P= .960	P= .903	P= .734	P= .854	P= .874	P= .958
PIONLY2	-.0874	.0707	.0417	.1839	.0568	.0133	-.2292	.0280	.1091	.0926	-.0566
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .714	P= .767	P= .862	P= .438	P= .812	P= .956	P= .331	P= .907	P= .647	P= .698	P= .813
PCANDPI	-.1611	-.0005	-.0379	.1755	-.0189	-.0006	-.1126	-.0404	.0325	.0801	-.0416
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .498	P= .998	P= .874	P= .459	P= .937	P= .998	P= .637	P= .866	P= .892	P= .737	P= .862
DBL_PC	-.1672	-.0259	-.0616	.1505	-.0436	-.0055	-.0568	-.0597	.0011	.0656	-.0310
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .481	P= .914	P= .796	P= .526	P= .855	P= .982	P= .812	P= .802	P= .996	P= .783	P= .897
ABSDIF	-.0733	-.0134	.0112	-.1250	-.0534	-.0499	-.1718	.1886	-.1019	.0155	.0613
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .759	P= .955	P= .963	P= .599	P= .823	P= .834	P= .469	P= .426	P= .669	P= .948	P= .797
REALDIF	-.0744	-.1027	-.1074	-.0469	-.1056	-.0200	.1907	-.0907	-.1171	-.0339	.0298
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .755	P= .666	P= .652	P= .844	P= .658	P= .933	P= .421	P= .704	P= .623	P= .887	P= .901
AD_BAD	-.1007	.0054	-.0360	.1982	.0075	.0211	-.0183	-.1147	.0707	.0591	-.0606
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .673	P= .982	P= .880	P= .402	P= .975	P= .930	P= .939	P= .630	P= .767	P= .804	P= .800
AD_GOOD	-.1928	-.0073	-.0310	.1061	-.0454	-.0260	-.1960	.0568	-.0204	.0853	-.0091
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .415	P= .976	P= .897	P= .656	P= .849	P= .914	P= .408	P= .812	P= .932	P= .721	P= .970
DBL_BAD	-.1414	.0017	-.0381	.1883	-.0091	.0078	-.0786	-.0701	.0480	.0738	-.0499
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .552	P= .994	P= .873	P= .427	P= .970	P= .974	P= .742	P= .769	P= .841	P= .757	P= .834
DBL_GOOD	-.1773	-.0029	-.0367	.1566	-.0288	-.0096	-.1454	-.0075	.0149	.0844	-.0315
	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)
	P= .455	P= .990	P= .878	P= .510	P= .904	P= .968	P= .541	P= .975	P= .950	P= .723	P= .895

STRESS SCALE

Correlations:	NAVTIME	DEVIATE#	%OFFCOUR	WITHIN	THRT#	THRTIME	THRTMAX	MEANDUR	ILSRIGHT
PCONLY	-.0542 (19) P= .826	.1681 (19) P= .492	.0694 (19) P= .778	.2649 (19) P= .273	-.1397 (19) P= .568	-.0272 (19) P= .912	.2778 (19) P= .249	.1305 (19) P= .594	-.0008 (18) P= .998
PIONLY	.2114 (19) P= .385	.1572 (19) P= .520	-.0271 (19) P= .912	-.2603 (19) P= .282	-.2977 (19) P= .216	-.3383 (19) P= .157	-.2035 (19) P= .403	-.1101 (19) P= .654	.1010 (18) P= .690
PCANDPI	.0775 (19) P= .753	.2060 (19) P= .398	.0346 (19) P= .888	.0457 (19) P= .853	-.2629 (19) P= .277	-.2051 (19) P= .400	.0861 (19) P= .726	.0325 (19) P= .895	.0566 (18) P= .824
DBL_PC	.0236 (19) P= .924	.1977 (19) P= .417	.0510 (19) P= .836	.1423 (19) P= .561	-.2200 (19) P= .365	-.1363 (19) P= .578	.1724 (19) P= .480	.0762 (19) P= .757	.0344 (18) P= .892
ABSDIF	.3447 (19) P= .148	.2776 (19) P= .250	.1033 (19) P= .674	-.4580 (19) P= .049	.4452 (19) P= .056	.4401 (19) P= .059	.4133 (19) P= .079	.1252 (19) P= .610	.2480 (18) P= .321
REALDIF	-.1969 (19) P= .419	.0425 (19) P= .863	.0819 (19) P= .739	.4222 (19) P= .072	.0814 (19) P= .741	.2118 (19) P= .384	.3942 (19) P= .095	.1954 (19) P= .423	-.0733 (18) P= .772
AD_BAD	-.0877 (19) P= .721	.0465 (19) P= .850	-.0171 (19) P= .945	.2379 (19) P= .327	-.4095 (19) P= .082	-.3601 (19) P= .130	-.1107 (19) P= .652	-.0283 (19) P= .908	-.0600 (18) P= .813
AD_GOOD	.2532 (19) P= .296	.3425 (19) P= .151	.0869 (19) P= .724	-.1930 (19) P= .428	-.0231 (19) P= .925	.0300 (19) P= .903	.2971 (19) P= .217	.0962 (19) P= .695	.1825 (18) P= .469
DBL_BAD	.0151 (19) P= .951	.1488 (19) P= .543	.0153 (19) P= .950	.1215 (19) P= .620	-.3261 (19) P= .173	-.2702 (19) P= .263	.0116 (19) P= .962	.0096 (19) P= .969	.0125 (18) P= .961
DBL_GOOD	.1420 (19) P= .562	.2608 (19) P= .281	.0541 (19) P= .826	-.0369 (19) P= .881	-.1869 (19) P= .443	-.1289 (19) P= .599	.1633 (19) P= .504	.0560 (19) P= .820	.1023 (18) P= .686